Wisconsin Karner Blue Butterfly
Habitat Conservation Plan and Environmental Impact Statement

Appendix F. Conservation Protocols and Guidelines for Karner Blue Butterflies

This appendix includes a variety of guidelines, protocols and methods related to implementation of the HCP. It is comprised of several documents that were prepared by the partners to support development of the statewide Wisconsin Karner Blue Butterfly HCP. These reports have been reformatted and reproduced here without editing.

Table of Contents

Some partners have outlined specific conservation measures in their conservation agreements. Other partners have agreed to follow the guidelines included in the HCP and the associated guidelines (i.e. this appendix). Others will do a mix of what is in the HCP (and Appendix) and their own approach. All commitments, however, are stated in the partners' conservation agreements, especially if they are to be different than what is included in the HCP.

In addition to the guidelines and protocols included here, readers are referred to the guidelines in the following two reports which some HCP partners have chosen to follow:

Lane, C. 1997. *Forest Management Guidelines: Developing Management Plans Compatible with Karner blue Butterfly Persistence*. Unpubl. Rept. to Wisconsin Dept. Natural Resources and U.S. Fish & Wildlife Service.

Weaver Boos Consultants, Inc. 1996. The Strategic Management Plan for Linear Corridors in Areas Inhabited by the Karner Blue Butterfly (*Lycaeides melissa samuelis* Nabakov). Unpubl. Rept. for the Linear Corridor Partners, Wisconsin HCP Team.

Due to the length of these documents and their limited application in the HCP, they have not been reproduced in this appendix. Copies of these reports are available for review at the USFWS Green Bay Field Office and the DNR Headquarters in Madison.

A. Karner Blue Butterfly Conservation Protocols for Forest Management by HCP Partners

Forest management in Wisconsin is an ongoing management practice which addresses existing forest rather than creating new forest land. Therefore, management in consideration of the Karner blue butterfly routinely commences with the decision to apply management to the landscape with individual forest stands which addresses land with habitat occupied by the Karner blue butterfly.

A conservation strategy for forest management on private and public land includes the "shifting mosaic" strategy. This strategy addresses incidental take by forest management which is designed to protect, maintain, and minimize adverse effects to, or assure the continued existence of Karner blue butterfly habitat in the state. Karner blue butterfly habitat may be lost through natural succession or as a result of management activities, and subsequently may reduce or prohibit Karner blue butterfly occupation of habitat. The strategy is designed to primarily benefit the species through a disturbance regime, a necessary requirement for Karner blue butterfly habitat. The landowner seeks to establish or shift habitat by working with or from occupied habitat. Steps will be taken by partners to maintain Karner blue butterflies on the landscape as a recruitment source of butterflies through measures designed to avoid or minimize harm to occupied lupine patches and/or insure occupied patches exist within dispersal distance of their project site. The occupied habitat serves as a source of butterflies, and at times, a source of lupine for new habitat that becomes established through land management in proximity to the occupied habitat. It is a landscape strategy, rather than site specific, meaning that not all occupied sites, or habitat, will be used in the strategy. It is anticipated that individual stands that are managed will often result in the extended longevity of occupied habitat as a by-product of the forest management. Management activities will occasionally result in a short-term loss of individuals with long-term benefits for the species. The forest landowners, by agreeing to apply this strategy, commit significant financial resources.

The monitoring and reporting requirements, consistent with the HCP and conservation agreements, allow review and analysis of the shifting mosaic management strategy and its effect on the Karner blue butterfly. This information, experience and knowledge will be included in the pool of information that feeds the HCP's adaptive management process.

The protocols described in this document follow a consistent format. First, a discussion occurs on where and how pre-management surveys will be done on HCP partner lands. These pre-management surveys are then considered the first step (step 1) in all of the forest management sections including harvesting, site preparation, regeneration, intermediate treatments, and roadside and openings management. After the pre-management survey step 1, steps 2 - 4 follow a consistent progression of three distinct protocol options. The protocol of avoidance of habitat (step 2), or the protection or enhancement of habitat (step 3), or the minimization of adverse effects (step 4) will occur individually or in combination (depending on the size and pattern) for

each site. The management examples that have been included in the various protocol steps are intended to serve only as an explanation of the protocol. Additional management measures are discussed in Part C of Chapter II (see section "Forest Management" on pages 81-84 in the HCP) and also in individual partner's conservation agreements.

1. Pre-Management Reconnaissance Surveys for Karner Blue Butterflies

On lands with the potential to maintain or support the Karner blue butterfly, consistent with the conservation agreements (normally land in the High Potential Range with existing potential to support the species and its habitat), partners agree in their conservation agreements to conduct reconnaissance surveys (typically in the growing season) prior to implementation of forestry management practices. Pre-management lupine and Karner blue butterfly surveys should be repeated if at least one growing season has lapsed since harvest and the management activity. If harvest of a mature stand of timber is the prescribed management activity, partners may conduct the pre-management survey up to five years prior to the harvest or 5-8 years with written justification.[C]

The intent of the pre-management surveys is to determine if Karner blue butterfly habitat is present in the stand. *Partners will be using the lupine survey protocols in the HCP Appendix, unless specified otherwise in their conservation agreements. Some partners have identified specific stand-level criteria (based on past survey experience) in their conservation agreements that reflect potential Karner blue butterfly habitat to guide their survey efforts.* Criteria used by partners include stand basal areas of less than 80 square feet, average crown closures of less than 75 percent when uniform dense shrub understories occur on less than 50 percent of the stand, and presence of an unoccupied Karner blue butterfly site adjacent to the stand. If lupine is found, consistent with established protocols, further surveys will be conducted to determine if the habitat is occupied.

2. Harvest

Based on the timber type and management goal or objective, a forest land manager may apply a variety of harvesting methods. The variables of the land, vegetation type, goals of land/forest management, and opportunities to 1) minimize adverse effects on the occupied habitat and species, and 2) promote habitat continuation or enhancement vary greatly with each stand.

Harvest considerations include:

a. Felling method;

b. Skidding method (avoid habitat, disturb or create openings for habitat);
c. Combined skidding and felling method;
d. Skid road and landing layout (level of shade, composition of vegetation, structure of vegetation, creation or enhancement of habitat;
e. Season and conditions;
f. Slash treatment;
g. Rotation length
h. Residual stocking levels;
i. Habitat site considerations; and
j. Other appropriate treatments.

Consideration of the Karner blue butterfly will then include:

1. Pre-management surveys to identify occupied habitat *and*

2. Avoiding the occupied habitat (which may ultimately be lost through natural succession of forest stands or other vegetation but act as Karner blue butterfly recruitment sources in the short-term); *or*

3. Apply otherwise lawful forest management practices that seek to protect or enhance[1] the occupied habitat, e.g. removal of competing timber or other vegetation, or the seeding of lupine crops; *or*

4. Apply the otherwise lawful forest management practice with the intent not to destroy the habitat but to achieve the forestry goal or objective while minimizing adverse effects.

In addition, forest partners intend to apply harvesting strategies to land currently not occupied but having the potential for occupation because of the proximity to occupied habitat which serves to replace habitat lost through active management or natural loss, even though they have no legal obligation to mitigate or replace habitat lost naturally (e.g., succession of competing vegetation).

3. Site Preparation

(To reduce competitive vegetation, expose mineral soil, and reduce logging residues [slash] to prepare the site for regeneration)

With forest management practices on existing forests, site preparation is more often part of a stand regeneration effort than the creation of forests. Site preparation includes:

a. Mechanical site preparation:
b. Chemical site preparation;
c. Prescribed fire; and
d. Other appropriate regeneration practices.

Consideration of the Karner blue butterfly will then include:

1. Pre-management surveys, if not done prior to harvest or other management activity, to identify occupied habitat *and*

2. Avoiding the occupied habitat (which may ultimately be lost through natural succession of forest stands or other vegetation but act as Karner blue butterfly recruitment sources in the short-term); *or*

3. Apply the otherwise lawful forest management practice designed to protect or enhance[1] the occupied habitat; *or*

4. Apply the otherwise lawful forest management practice with the intent not to destroy the habitat but to achieve the forestry goal or objective while minimizing adverse effects.

4. Regeneration

(The establishment of young forests)
Regeneration methods include:
a. Method of regeneration either artificial (seeding or planting) or natural;
b. Featured selected species; and
c. Stand density

Consideration of the Karner blue butterfly will then include:

1. Pre-management surveys, if not done prior to harvest or other management activity, to identify occupied habitat *and*

2. Avoiding the occupied habitat (which may ultimately be lost through natural succession of forest stands or other vegetation but act as Karner blue butterfly recruitment sources in the short-term); *or*

3. Apply otherwise lawful forest management activity designed to protect or enhance[1] the occupied habitat; *or*

4. Apply the otherwise lawful forest management practice with the intent not to destroy the habitat but to achieve the forestry goal or objective while minimizing adverse effects.

Typical regeneration activities which affect occupied habitat, with its associated disturbance and resulting openings, are expected to provide areas for habitat establishment.

5. Stand Improvement

Based on the timber type and management goal or objective, a forest land manager may apply intermediate stand management practices, including:

a. Release treatments;
b. Chemical release (with the use of herbicides or application protocols or the findings of research);
c. Methods of thinning;
d. Pruning;
e. Pest and pathogen control (e.g. jack pine budworm, oak wilt, 2-lined chestnut borer);
f. Fertilization; and
g. Other appropriate stand management practices.

Consideration of the Karner blue butterfly will then include:

1. Pre-management surveys, if not done prior to harvest or other management activity, to identify occupied habitat *and*

2. Avoiding the occupied habitat (which may ultimately be lost through natural succession of forest stands or other vegetation but act as Karner blue butterfly recruitment sources in the short-term); *or*

3. Apply otherwise lawful management practices that are designed to protect or enhance[1] the occupied habitat; *or*

4. Apply the otherwise lawful forest management practice with the intent not to destroy the

habitat but to achieve the forestry goal or objective while minimizing adverse effects.

6. Roadside and Openings Management

Periodically, the vegetation within or adjacent to roadsides and/or openings are managed. Management practices may include:

a. Mowing;
b. Herbicide treatments; and
c. Enhancement/creation of dispersal corridors.

Consideration of the Karner blue butterfly will then include:

1. Pre-management surveys, if not done prior to harvest or other management activity, to identify occupied habitat *and*

2. Avoiding the occupied habitat (which may ultimately be lost through natural succession of forest stands or other vegetation but act as Karner blue butterfly recruitment sources in the short-term); *or*

3. Designing and managing roadsides and openings, and possibly planting lupine seed, to protect, enhance[1] or create habitat, especially in close proximity to occupied sites; *or*

4. Designing and managing roadsides and openings to minimize their adverse effect on occupied habitat while achieving the forest management goal or objective of the owner.

An important element with all of the conservation protocols is that forest management activities will occasionally result in a short-term loss of species individuals or habitats. The short term loss will be rewarded with the longer-term benefit of disturbance resulting from the activity. However, the longer-term benefits may still be limited for a period of time as the forest stand reaches an age and size where lupine is gradually lost and the habitat value is again reduced. This moving and shifting mosaic strategy is continuous throughout the life of the ITP and will not depend on a one-time application of disturbance.

---

[1] Protect or enhance in these protocols means that Karner blue butterflies are featured on the site even though the overall strategy chosen by the partner for that specific property may be management with consideration.

B. Wildlife Management Guidelines for the Karner Blue Butterfly

The guidelines included here were developed by the Wisconsin DNR in consultation with the HCP Biological Team. The guidelines were finalized in a report titled "Wildlife Management Guidelines for the Karner Blue Butterfly" published by the DNR in May 1998. This report has been reformatted and reproduced here without editing. References to appendices in this part refer to appendices to the original report, not the appendices of the HCP or EIS.

1. Introduction

These management guidelines are intended for use on public or private areas known or have the potential to support the Karner blue butterfly (*Lycaeides melissa samuelis*).

Wisconsin possesses a great number and variety of Karner blue habitat conditions. Varying resource management capabilities exist across these areas. Consequently, these guidelines are designed to allow for the use of professional judgment and discretion, and integration into overall land-use goals. These guidelines also allow for flexibility to respond appropriately to unpredictable influences such as weather, pest outbreaks, annual Karner blue population fluctuations, or changes in staff or funding needed to accomplish management.

Guidelines under each major section are based on current knowledge and expectations of results. The guidelines are divided into two types: "REQUIREMENTS" or "RECOMMENDATIONS". Those practices designated as "REQUIREMENTS" are considered to be the minimum measures necessary to protect populations. Practices designated as "RECOMMENDATIONS" are strongly encouraged, and often will be expected to go much further toward Karner blue protection and recovery, however their actual applications are left to property owner or manager discretion.

These guidelines are based on current levels of knowledge of the biology and ecology of the Karner blue butterfly and its habitat, and on our limited knowledge of the effects of various wildlife management practices. As more information becomes available over time through research and monitoring, revisions will undoubtedly become necessary. The current guidelines were revised in May, 1998 and reflect the state of knowledge at that time on Karner management.

Permit Requirements under the U.S. Endangered Species Act

The Karner blue butterfly was federally listed as endangered in December, 1992. It is not state-listed at present (it is of "Special Concern" in Wisconsin), therefore no state permits are needed for activities conducted in occupied habitat.

The federal Endangered Species Act (ESA) prohibits the "take" of the Karner blue butterfly without a permit from the U.S. Fish & Wildlife Service (the Service). "Take" includes harming,

harassing, killing or collecting any of the Karner blue's life stages (egg, larva, pupa or adult).

Under Section 10 of the ESA, the Service also has the authority to issue permits for "incidental take" of the Karner blue, for activities incidental to otherwise lawful activities that result in some "taking." Examples of types of activities that could involve "incidental take" include forestry activities, power line maintenance, residential development, road construction, and recreational activities such as hiking, ATV use, hunting, and berry picking. Conducting these activities in lupine areas occupied by the Karner blue may result in loss or adverse impacts to lupine plants and thus possible mortality of Karner blue eggs, larvae, and/or pupae. "Incidental take" permits require the development of a Habitat Conservation Plan (HCP). This permit process is much more involved than the recovery permit process.

The Wisconsin DNR is lead in the development of the Wisconsin Statewide Habitat Conservation Plan for the Karner Blue butterfly. This HCP is intended to cover the incidental take of Karners due to a wide variety of activities, including those noted above. It is anticipated that the Service will issue an incidental take permit sometime in 1999. This would allow for the "take" of the butterflies in compliance with the terms and conditions of the permit and the conservation program spelled out in the HCP. Where an activity will not impact an occupied wild lupine area, no permit is required.

2. Landscape-Scale Management Goals for the Karner Blue Butterfly

The ultimate goal of management for the Karner blue butterfly is the recovery of its metapopulation dynamics on large-scale landscapes supporting functioning native oak and pine barrens ecosystems.

[Metapopulations are ensembles of dynamic and interacting local populations.]

Large-scale oak and pine barrens restoration and management would be expected to benefit a host of species native to this imperiled community that, like the Karner blue, have also declined dramatically. Management at this scale should be directed toward recovery of a natural barrens landscape mosaic and should promote a full complement of its native ecosystem components, rather than aiming solely to maximize absolute numbers of Karner blue butterflies. Management efforts at this level should aim to first identify and maintain or enhance *extant* native communities and populations prior to any community restoration or re-creation efforts, or introduction or reintroduction of butterflies.

Opportunities for large-scale barrens restoration are great throughout the Karner blue range in central and northwestern Wisconsin. As such, management and recovery of the Karner blue will involve exploring opportunities for restoration and management of large barrens landscape mo-

saics. The larger the area, the greater the likelihood for long-term persistence of the community and its dependent species with the least intensive management. *See "Guidelines Specific to Landscape-Scale Management Regime Design," under Section IV, below.*

3. Inventory and Monitoring

The first step toward a management plan is inventory. The Wisconsin Natural Heritage Inventory Program, within the DNR's Bureau of Endangered Resources, maintains current maps and computer databases of all historical and extant Karner blue occurrences in Wisconsin. Contact Bureau of Endangered Resources for the Natural Heritage Inventory Data Manager, Julie Bleser, at 608/266-0394, for information on known sites in your area *or to report newly discovered sites.*

Areas known or suspected to support Karner blue populations (see below) must be surveyed prior to *any* activity likely to affect the animal or its habitat, including wildlife management practices. At minimum, two surveys are required: wild lupine reconnaissance and a survey for the presence or absence of the animal. For those areas where Karner blue butterflies are found and management activities are planned, a third type of survey is necessary, that of pre- and post-treatment transect-walk surveys of butterfly relative abundance to monitor the effectiveness of applied management practices.

Likely Habitat for the Karner Blue in Wisconsin. The Karner blue butterfly is found on areas with sandy soils supporting remnant pine/oak barrens or sand prairie with fairly dense stands of wild lupine (*Lupinus perennis*), its sole larval food plant. Old-fields, power line and roadside rights-of-way, young forest stands or plantations, and edges or semi-openings within more forested areas also support Karner blues in Wisconsin.

Wisconsin Range. Wisconsin's known Karner blue populations are concentrated across the Central Sands counties, from Waupaca County south to Green Lake County and west across the central tier of sand counties to Dunn County. Additional populations are known from northwestern Wisconsin, primarily in Burnett County, where lupine appears to reach the northern edge of its range. More recently, populations have been discovered in Menominee County and Kenosha County. The barrens of northeastern and north-central Wisconsin are not known to support wild lupine.

Requirements

Areas known or suspected of supporting likely habitat for the Karner blue butterfly must, at a minimum, be surveyed for lupine and the presence or absence of the animal prior to initiating any management. (Even unintentional or unknowing "take" in occupied habitat is prohibited by federal law without a permit.)

Refer to "General Survey Information & Conditions for the Karner Blue Butterfly," in Appendix I., for information on survey of Karner blue butterfly populations.

Contact the Wisconsin DNR Bureau of Endangered Resources (Kathryn Kirk, 608-266-0545) for more information on identifying Karner blue habitat and life stages. Training sessions are offered periodically around the state.

Survey Procedure

A. Step 1: Wild Lupine Reconnaissance

   Karner blue habitat is always characterized by the presence of wild lupine. Surveys of likely areas of habitat for wild lupine are possible beginning in early May, however most lupine surveys are conducted from late May to mid-June when flowers are most detectable.

   See "Recommendations for Conducting Wild Lupine Surveys" in Appendix II.

   If an area supports no wild lupine, no further surveys are needed. If an area supports only very sparse, scattered lupine plants at an average density of less than 25 plants or clumps per acre, further Karner blue butterfly surveys may not be required. Refer to Step 2. Below.

B. Step 2: Karner Blue Presence/Absence Surveys

   If an area supports wild lupine at a minimum density of 25 plants or clumps per acre that are within 450 meters of denser lupine areas with possibilities for dispersal, conduct surveys for the Karner blue. If such areas are separated from denser stands by obvious dispersal barriers, no further surveys are required. (However, they are recommended--*see RECOMMENDATIONS below*). Based on current knowledge, at least 200 feet of dense forest constitutes the most common type of dispersal barrier. Also, if definitive Karner blue larval feeding damage on lupine is observed by a trained individual, surveys should be conducted for the Karner blue.

[In Wisconsin studies, female Karners were rarely recorded having moved further than 400m. from their home lupine patches.]

First-time adult surveys of potential habitat must always include the second flight (July and August) when more individuals are usually evident than during the first flight, unless butterflies and/or larvae have been observed on the site earlier in the season; second-flight surveys may also pick up any animals that have immigrated to the site after the first flight from any populations that may exist nearby.

Refer to "KBB Survey Protocol--Presence/Absence Surveys" in Appendix III. for survey techniques.

C. Step 3: Transect Count Monitoring Surveys

Where management activities that may impact Karner blue populations are planned, pre- and post-treatment monitoring surveys are required by the U.S. Fish & Wildlife Service for issuance of any take permit. The number of Karner blue butterfly generations to be included in such monitoring will vary somewhat according to the capabilities of each landowner/manager, and must be worked out on a case-by-case basis.

The WI DNR and the Service will rely on long-term management monitoring programs at selected sites to provide information needed to guide future management policies.

1) At a minimum, plan to monitor the generation immediately preceding management, and at least the second flight adults for each of the subsequent 2 years following management.

   A longer duration of pre- and post-management monitoring is preferred. Yearly Karner blue population fluctuations apart from management (usually correlated with weather patterns) can be quite extreme. Long-term monitoring allows the collection of enough count data to infer an *average* relative abundance for a given site.

   A standard Pollard-Yates type walk-through survey should be used to assess the impact of management activities on the Karner blue (use during pre- and post management monitoring efforts). Refer to Appendix VI. for protocols.

   Once the permit has been issued for implementation of the Wisconsin Statewide HCP, additional effectiveness monitoring will be done on various state properties using the straight-line transect method to monitor relative abundance of the Karner blue on a statewide basis. Additional lupine and KBB P/A monitoring may also be done on various state properties.) Monitoring protocols developed by the Wisconsin Karner Blue HCP Monitoring Subteam and data collection forms are available from the WI

DNR, Bureau of Endangered Resources for these additional monitoring efforts.

A survey of affected habitat areas using the transect count method developed by the Wisconsin Karner Blue HCP Monitoring Committee is to be used for monitoring changes in relative abundance for a given site over time. Data collection forms and monitoring protocols are available from WI DNR. Contact the Bureau of Endangered Resources.

[Contact WI DNR if you require assistance in order to conduct such surveys.]

2) Based on monitoring surveys, map the distribution of lupine and Karner blue populations across a site (at a minimum, on a topographic map and/or aerial photo). If possible, indicate areas with the highest lupine and butterfly population densities.

   Also include in maps areas with nectar plants, especially butterfly weed *(Asclepias tuberosa)*, which is a highly-attractive and heavily-used nectar plant for adult Karners. If adult uses of nectar plant patches outside the main lupine areas are observed, map these nectar patches as well. Such a map will be vital to designing a management regime.

   [An adequate supply of nectar from flowering plants is necessary for adults. Adults only sip fluids, and rely completely on nectar for energy to reproduce. See the table of "Nectar Plants Species used by the Karner Blue Butterfly" in Appendix IV.]

3) Report monitoring survey results to Wisconsin DNR. These survey results will be incorporated into an annual report to the Service and used to update the Karner blue data within the DNR's Natural Heritage Inventory.

Recommendations

A. It is recommended that Karner blue surveys (at least presence/absence) be conducted on areas supporting *any* amount of lupine--especially throughout the Central Sands area of the state where populations are most highly concentrated. Document the approximate density of lupine for such surveys.

B. Document habitat utilization by Karner blues: identify and map lupine areas with heaviest feeding damage, or lupine patches where most oviposition behavior by adult females is observed.

   Document areas of concentrated adult nectaring activity, and of preferred nectar plants. Map these areas for use in designing a management regime.

C. Establish more formal fixed transects, or plots containing variable transect routes for systematic long-term and/or recovery monitoring of Karner blue relative abundance. Recovery monitoring will entail establishing a monitoring program to assess whether KBB numbers have reached the level identified as necessary in the KBB Recovery Plan to maintain a viable population.

   Consult with WI DNR and the Service when developing long-term monitoring plots.

D. Habitat Assessment: It is strongly recommended that some degree of habitat assessment accompany presence/absence surveys, and especially monitoring surveys conducted to assess the effects of management activities.

   Refer to "Karner Blue Butterfly Habitat Evaluation Protocol" in Appendix V. for information on assessing habitat.

E. Delineate on a map or aerial photo different micro-habitats within a site. Such information will be very important in designing a management regime. Examples include shaded vs. open areas; lower and wetter areas vs. higher, drier ridges; different slopes and exposures; and varying degrees of disturbance/degradation.

F. Where time and resources permit, more formal habitat sampling is recommended. Contact Kathryn Kirk, WI DNR, or Rich Henderson, Bureau of Research, WI DNR for more information on sampling techniques.

4. Designing a Management Regime Considering the Karner Blue Butterfly

The Karner blue butterfly is native to a disturbance-dependent community, with fire and herbivory presumed to be the primary historical disturbance factors. Its sole larval food plant, wild lupine, generally responds very well to fire or other disturbance and does not appear to thrive in heavier shade. At the same time, evidence has shown that the Karner blue life stages present in a burned area incur heavy mortality. Patchy or fast-moving, light fires may leave some survivors.

Great caution is needed with the use of fire and, to a lesser extent, with other management techniques such as appropriately-timed mowing and brushing. Particularly the frequency, timing, and extent of burns should be carefully considered. At least some portion of the native invertebrate fauna (particularly Lepidoptera) will suffer mortality in burned areas. The percentage of invertebrate species that will suffer direct or indirect harm from fire or other disturbance is unknown, however it will vary with the seasonal timing and intensity of the disturbance.

Like the Karner blue, most butterfly and many other insect species native to disturbance-adapted communities depend on the ability of populations either to survive the disturbance at some level, or to recolonize habitat from untreated areas nearby.

Management design and implementation must take many factors into consideration, including:

-Apparent size of the Karner population

-Size (or potential size) of habitat

-Context of the habitat within the landscape: (e.g., habitat surroundings, potential for habitat diversity, compatibility of current land-uses, etc.)

-Proximity to other populations
-Equipment and personnel available

-Cost

-Expected overall ecosystem benefits: (e.g., expected effects of various management treatments (or no treatments) on both overall vegetative structure and composition *and* on various faunal components)

-Potential of site to support a viable Karner blue population

-Landowner goals and objectives, short-term and long-term

-Other biodiversity concerns (e.g., impacts on other rare species, or on possible exotic or "pest" species)

Management regime design will to a large extent depend on the professional judgment, and time and resource capabilities of the property manager or landowner.

Requirements

A. Plan never to apply any management treatment that is likely to have some adverse impact to an entire Karner blue population or metapopulation within the time-frame of only two or fewer consecutive generations. (Be aware that only a single Karner blue generation is present from the fall of one year through the spring of the next.)

B. Divide each occupied Karner blue habitat area into separate management units. This requirement applies to mowing, herbiciding, or other treatments as well as to burning. The number, design, and rotation of management units should allow for effective Karner blue reoccupation of treated areas from nearby untreated areas.

   See Section V. "Management Tools and Techniques Considering the Karner Blue Butterfly" below for further guidelines.

C. Plan to apply prescribed fire or any other management tool *only according to habitat need*, rather than at a fixed return interval regardless of the condition of the habitat or Karner population. Do not treat more frequently or extensively than is necessary for maintenance and enhancement of the entire community *including* the fauna. Do not presume that because the vegetative component of a site appears to be benefited that the Karner blue and other fauna are also benefiting. (The faunal responses to management must be directly monitored).

D. Conduct pre- and post-treatment Karner blue surveys.

   Refer to Section III. "Inventory and Monitoring" above for information on conducting monitoring surveys.

   Plan to monitor the effects of various management treatments on Karner blue populations throughout the planning horizon, to document treatments and observed responses, and to report the information to the Bureau of Endangered Resources. The information will be included in an annual report to the U.S. Fish & Wildlife Service. Shared results will increase the knowledge base for all parties concerned about management effects on Karner blues.

   Future management decisions should be based on results of the most recent monitoring and the apparent successes or failures of past treatments.

E. Remain as flexible as possible, and incorporate as many alternatives as possible into management planning. If weather or other factors alone cause population declines, then management plans may need to be modified. For example, population crashes due to poor weather may call for a delay in prescribed burning, or the use of appropriate mowing or spot-herbicide treatment instead.

Recommendations

A. Management unit design: Divide lupine areas, Karner blue population concentrations, various micro-habitats present, and important nectaring areas as evenly across management units as possible. Avoid placing important resource areas or the majority of a population entirely into a single unit. Promote habitat diversity *within each unit. See also "C" below*.

B. Promote irregularly-shaped units, rather than more circular or block-shaped units, to maximize the treatment area boundary and minimize the distance over which Karners and other animals must travel to completely recolonize treated units.

C. Promote overall habitat diversity throughout a site, rather than a uniform vegetational structure. Attempt through management to provide areas offering shade as well as full sun, wetter habitats as well as drier, etc., so that Karners and other habitat-restricted animals are able to meet their resource requirements under varying conditions over time.

[Research has indicated that partially shaded lupine areas, with 30-60% canopy cover and in some cases over 70% canopy cover are preferred by Karners for oviposition and also may support greater numbers of larvae surviving to adulthood.]

D. Incorporate a variety of management treatments and times of treatments into the management regime to maximize habitat diversity and biodiversity.

1) Apply a variety of management tools and techniques. Incorporate mowing and/or brush and tree cutting or girdling according to site-specific needs as an alternative or complement to prescribed burning (perhaps with spot-herbicide treatments). Light or rotational grazing may also be explored as an alternative or complement to fire.

2) Vary the timing of management treatments in accordance with site-specific needs to encourage greater habitat- and species-diversity. Avoid creating a uniform landscape and selecting for species favored by repeated use of the same technique during the same time of year.

See Section V "Management Tools" below for further guidelines.

E. Manage for barrens on *unoccupied* areas adjoining or very near, known Karner blue populations to expand habitat. (If fire is being used, then this should be in addition to one non-adjacent occupied unit.)

F. On very small sites (less than about 5 acres), isolated from any additional Karner blue habitat and that support very low observed numbers of Karner blues (less than about 25 adults at peak summer flight), mechanical and/or chemical management is recommended as an alternative to fire.

See "Guidelines Specific to Landscape-Scale Management Regime Design" below.

Also, if surrounding land-use allows, consider management to expand habitat around these small islands prior to treatment.

G. On very dry, sandy, exposed sites with very little accumulation of plant litter and minimal woody encroachment (scattered brush or trees is fine), no immediate management may be needed. Burning such sites may, in fact, only exacerbate the droughty conditions and cause premature lupine senescence.

Guidelines Specific to Landscape-Scale Management Regime Design

Recommendations

Criteria for large-scale habitat restoration and metapopulation management projects are presented below. Several such large-scale areas would be desired for ultimate recovery of the Karner blue. Metapopulation criteria as presented here are drawn from the March 1997 "Working Draft" Karner Blue Butterfly Recovery Plan" which includes management guidelines for the Karner blue butterfly. For information on recovery planning or management considerations contact the Service.

A. Minimum area requirements:

Viable metapopulations: The minimum area necessary for establishing a (minimum) viable metapopulation is unknown, however it is recommended that it contain at least 3-5 (and preferably more) local subpopulations (or demes) and that each occupied site (subpopulation) be greater than 0.25 hectares (0.62 acres) in size. To reduce the problem of extirpation at these small sites, habitat could be managed to support a high population density of Karner blues (many host plants, nectar sources, and good

mircohabitat). Ideally, several more than 3-5 subpopulations should be established over a larger landscape when designing a (minimum) viable population to buffer against

stochastic events and minimize extirpation.

Large viable metapopulation: A large viable metapopulation should cover an areal extent of at least ten square miles containing about 640 acres of suitable habitat; the suitable habitat should be distributed over two-thirds of the ten square mile area. The average distance between sites should be one kilometer (0.62 miles) with a minimum distance of 200 meters (219 yards) and a maximum distance of 2 kilometers (1.24 miles).

B. Metapopulation size:

Viable metapopulation: A (minimum) viable metapopulation should have at least 3000 first or second brood adults with each subpopulation supporting at least 300-600 individuals. It is important that these subpopulations be linked together into a larger metapopulation to promote gene flow.

Each local colony or subpopulation should be contained within its own separate management unit, which may or may not be subdivided into separate treatment areas, and should be large enough to be capable of recolonizing neighboring burned or otherwise treated areas.

Large viable population: A large viable metapopulation should include at least 6,000 first or second brood adults.

C. Habitat diversity: Restore and manage barrens to promote a variety of vegetative structures including brush prairie, oak and pine savanna (with large, open-grown trees), older jack pine or oak woodlands, etc. The barrens landscape also should include open grassland (sand prairie), and, if possible, may include wet areas such as marshes, ponds, lakes or streams.

Design landscape areas to promote variation in degrees of canopy cover, slope and aspect, dominant vegetative community, soil moisture, etc. This habitat diversity offers buffers to climatic extremes and other stochastic events over the long-term, and favors overall species diversity.

D. Connecting isolated colonies to promote gene flow: Where subpopulations are within possible dispersal distance (about 1 mile) on the landscape, but separated by inhospitable habitat and/or barriers to dispersal such as dense brush or forest, promote connection of separate openings by cutting or thinning, or establishment of habitat corridors between major colonies to allow for population exchange.

Habitat corridors will be created or enhanced with clearing of woody growth and/or plantings of lupine and preferred nectaring forbs along rights-of-way, trails, logging

roads, fire breaks, etc.

E. Buffering of metapopulation: The metapopulation should be buffered against actual and potential local and large-scale adverse disturbances and threats to survival. Such threats include unusual weather, wildfires, and development of habitat for alternate uses e.g. residential, commercial, roads building, etc. Management plans should include provisions to address these threats. As noted under Habitat diversity (above) providing a heterogenous habitat can act to buffer against such events as climatic extremes and other stochastic events.

F. Management and monitoring plan: The Service's March 1997 "Working Draft" recovery plan recommends that a management and monitoring plan should be developed for each metapopulation. That plan should include: 1) monitoring of Karner blue numbers (to determine if metapopulation goals are met), 2) provide for suitable buffering of the metapopulation, 3) provide for maintenance of a diverse and appropriate successional array of suitable habitat, and 4) identify appropriate management responses to potential metapopulation declines.

See Section V. "Management Tools and Techniques Considering the Karner Blue Butterfly: D. Expansion of Habitat through Plantings" below.

5. Management Tools and Techniques Considering the Karner Blue Butterfly

Prescribed Fire

Prescribed fire currently is the most widely used and accepted tool for barrens management, and may be considered for use on any Karner blue site, providing adherence to the requirements below.

Fire can have variable effects on community structure and composition, depending on the type and timing of the burn, the type of habitat being burned, and interactions with factors such as weather fluctuations (e.g., drought), soils, and other disturbance such as grazing.

Possible Outcomes of Fire Management

Positive

Prescribed fire may benefit Karner blue habitat in the following ways:

- Increased density, above-ground biomass, flowering, and seed production of wild lupine and possibly other legumes

- Increased seed germination and seedling establishment of wild lupine, depending on the timing of the burn, as well as that of other native annual and perennial plants including nectar plants and decreased time needed for lupine seeds to germinate

- Increased flowering of nectaring plants

- Possible benefits where competition from weedy species is minimal from nutrients available through increased subsurface microbial activity stimulated by warmer soil, and immediate nutrient availability in ash.

  [Generally nutrient availability from ash is believed to play a very minor role in grasslands, however on areas with very sterile soils such as many of the sands supporting wild lupine, the role may be more significant.]

- Higher nitrogen content in the plant tissue of lupines *(found in an Ohio study, however cause unknown--perhaps through fire's effects on nitrogen fixation)*

- Control and/or suppression of woody vegetation

- Control of Eurasian cool-season grasses to the favor of native warm-season grasses

  More study is needed on control of invasive vegetation --see "Reported Effects of Burn Timing" under "Timing of Burns," below.

Negative (or Neutral)

Fire is also known to have some negative effects, and the habitat benefits may be insufficient to justify its use. The timing of a prescribed fire may play a crucial role:

- *Heavy mortality of Karner blue eggs, larvae, pupae or adults present in burned area*

- Mortality of other invertebrates present in burned area (effects variable, depends on timing of burn as well)

- Heavy mortality of lupine seeds and seedlings present on or above the soil surface during a burn *(found in an Ohio study)*

- May not reduce woody encroachment by oaks, hazel, sweet fern, etc., and may even encourage brush through resprouting

- Increased drying of soils and hastened senescence of wild lupine so adequate foliage is possibly not available to second-generation larvae and ovipositing adults--applies generally to very dry sites and during drier-than-average years

- Removal of litter may increase exposure of developing eggs, larvae to heat, frost, predators, etc., and remove the micro-habitats occupied by certain animals thus reducing niche diversity

- Increased productivity of native warm-season grasses, especially from cool-season fires, which could be expected to eventually out-compete flowering plants

- May set back some flowering plants important for nectaring (varies with timing of burn)

- May lead to increased erosion, particularly of exposed, burnt soil

- Heavy machinery such as water trucks may cause soil compaction

The main benefits of fire are believed to stem from its role in reducing accumulated plant litter, exposing bare soil, promoting increased soil temperatures, and setting back growth of plants that compete with native, desirable vegetation. Some of these effects may be achieved or enhanced with alternative management tools alone, in combination, or alternatively with fire. Because some degree of Karner blue and other invertebrate mortality is to be expected from fire (mortality of Karners and some other invertebrates may indeed be very high), it should be used very cautiously, especially until further research and monitoring help elucidate the long-term costs and benefits of this tool.

Requirements

A. Number of burn units: Divide contiguous Karner blue breeding habitat into a minimum of *3 burn units* (more if feasible) for a small metapopulation near the minimum viable population size criteria. For metapopulations nearer the large viable size and inhabiting habitat over several square kilometers, swaths of habitat may be managed as single management units as long as occupied areas nearby can provide individuals to repopulate the management unit.

*["*Contiguous*" Karner blue breeding habitat is the total extent of an area supporting wild lupine (even if patchy and scattered) that is occupied by the Karner blue and uninterrupted by obvious barriers to adult butterfly dispersal (usually dense forest). Presume adults to be quite capable of dispersing* at least *300 meters over open areas of suitable habitat, and so include such areas as "contiguous".]*

Never burn an entire population at one time. S*ee Section IV-B above*. For each prescribed burn, leave at least 2 unburned units with an adequate firebreak between them to protect against wildfire or other chance events that may diminish below viable levels, the population on the untreated areas.

Where burn units are larger (i.e., greater than about 40 acres), maintain over the longterm an unburned refugium (a small portion of occupied lupine habitat) within the burn unit by alternative management such as appropriate mowing and herbicide use, or simply exclude an occupied lupine area during a fire for the short-term (by watering down an area prior to burning, for example). Such a measure will promote greater Karner population survival and facilitate post-burn Karner recolonization throughout the treated unit.

B. Rotation: Design burn rotations so that populations can rebuild numbers on burned areas before adjoining source colonies are burned. *For small metapopulations, leave at least 1 of the units adjacent to a burned unit in the condition of having been untreated for the previous 3 years.*

[Rebuilding the population for Karners appears to take at least 2 years, under favorable weather conditions*. Population buildup for other invertebrate species that complete only 1 generation per year presumably will take longer.*]

Annual monitoring of relative abundance both pre- and post-treatment will be necessary to determine average population levels and apparent recovery from treatment.

See Section IIIC."Step 3: Transect Count Monitoring Surveys", above.

[Caution: Delay burning if populations decline severely due to weather or other factors (wildfires, flood, etc.)] Burn first the most degraded habitats supporting the fewest Karners, as habitat needs permit.

Recommendations

A. Burn Frequency: The optimal burn frequency per burn unit, with respect to the Karner blue, is no greater than once every 4 years, to allow populations ample time to recover through buildup from adjacent colonies. Burn frequencies of once every 5-10 years are preferred, unless woody succession or exotic invasion poses a more serious threat.

If sites are being burned more frequently than 4 years, consider alternatives. Substitute treatments such as mowing. Explore possibilities for excluding lupine colonies or patches which support the most Karners from burns (e.g., by burning around them). Maintain refugia within units through appropriate mechanical and/or herbicide management that leave significant portions of the population within a unit unharmed.

Burn Frequency for Metapopulations Occupying Large-Scale Barrens Landscapes. or large-scale sites where metapopulation management is underway, the ideal fire frequencies per local deme or subpopulation is no more than once every 5 years.

As always, monitor recolonization of burned areas and buildup of subpopulation levels before subsequent burning of same subpopulation.

B. Firebreaks: Utilize existing artificial or natural breaks such as trails, wetlands, or roads, as much as possible.

Avoid creating mineral breaks. While lupine may readily colonize the bare soil, so may other aggressive exotics. If mineral breaks are necessary to protect human safety, use rotovated or disced breaks rather than fire-plowed breaks. Caution must be used to avoid spreading seeds of weedy plants via equipment.

Monitor for potential invasion of aggressive exotic plants such as spotted knapweed or leafy spurge, and remove such invaders as soon as detected.
Contact the WI DNR's Bureau of Endangered Resources, 608/266-7012 to receive a copy of the "Draft Invasive Species Control Manual" for more information on control of weedy invaders. Be sure to follow pesticide use guidelines specific to the Karner blue *See "Pesticide Use," below.*

C. Type of Burn: Vary the degrees and intensities of burns. Allow or even aim for patchy burns, leaving a mosaic of burned and unburned areas whenever possible and compatible with overall needs of the habitat.

Consider leaving unburned a large lupine/barrens opening near the center of a management unit, to facilitate post-burn Karner blue recolonization throughout the unit, particularly for larger, more block-shaped units.

D. Timing of Burns: Fire is known to have different effects depending on when it occurs. To avoid selectively favoring some community components over others by repeated application of fire during the same time of year, vary the timing of prescribed burns to the extent weather permits.

[Since many of the invertebrate species inhabiting a grassland community probably overwinter in dormant life stages close to or in the soil and under snow compaction, early spring burns may have the least negative impact to the most invertebrate species, however more research is needed to acquire such life cycle information on invertebrate fauna .]

Reported Effects of Burn Timing

Dormant season burns (spring and late fall) typically are used to curb Eurasian cool-season grasses and increase native warm-season grasses (such as big and little bluestem) and summer-blooming native forbs. Late-spring burning when the cool-season grasses are in active growth, is by far the most effective time to burn to achieve these ends, followed by early spring burning. Fall burning is least effective for control of Eurasian cool-season grasses and encouragement of native summer grasses and forbs.

On much of the barrens and brush prairie habitat in Wisconsin, dormant-season burns have not appeared to curb encroaching scrubby oak or other woody brush, however. In fact, frequent fires on these areas may even stimulate denser brush thickets due to increased resprouting. Dormant-season burning also may stimulate sweet fern, which can exclude lupine and other prairie elements.

Many managers and observers have suggested that growing-season burns which could simulate naturally occurring lightning season burns, may set back woody growth much more effectively than dormant-season burns (documented research on this treatment is greatly needed). Growing-season burns also may favor flowering in some species not favored during spring or fall burns.

Summer burns would certainly have very different effects on the fauna present than would dormant season burns. Some invertebrate groups or species that overwinter as eggs or larvae on plants or in plant litter are vulnerable to spring and fall burning, but will be in a more resistant life stage during the summer. These species would be adversely affected or extirpated by repeated use of only dormant-season burning.

Karner blue adults are sedentary, and are weak fliers. They are expected to incur mortality from a summer burn; however, they have at least some physical ability to flee a fire and reproduce on adjacent lupine areas. Populations with eggs and larvae that are present on lupine between the two flight periods during a burn in June and July can be expected to be heavily impacted.

[*A study on two habitat sites at Necedah National Wildlife Refuge showed that some Karner blue adults survived fire treatment. However, proportions of survivorship varied widely with 86.7% observed on one site and 15.0% on the other site.* Much more research is needed in this area.]

Employ spring, summer, and fall burns to the extent possible, and as called for by the habitat condition and desired improvements. *Monitor and document the effects of variously timed burns on the overall community as well as on the relative abundance of Karner blues.*

Mechanical Management

As discussed above, many of the effects of fire on Karner blue habitat may be achieved through mechanical management. Historically, grazing and browsing by large ungulate herds (bison, elk, deer) undoubtedly played a significant interactive role with fire and climate in maintaining our prairie and barrens lands.

[Some long term butterfly monitoring conducted throughout the Midwest shows a much higher relative abundance and diversity of grassland-specialist butterflies on areas that are hayed, mowed or lightly grazed, or left untreated than on areas that are regularly burned.]

Mechanical management tools such as cutting, girdling, mowing, and bush-hogging may be used to simulate aspects of historical grazing and browsing and even to achieve many of the effects of fire, such as reducing litter accumulation (therefore reducing the fuel load for subsequent fire), opening ground for seed germination and seedling establishment, and curbing growth of competing woody and herbaceous plants.

Many of Wisconsin's Karner blue populations and other barrens-associated lepidoptera are found on power line and roadside rights-of-way, maintained solely by mechanical,and sometimes chemical, means.

[A large Karner population at an airport in New York is maintained solely by mowing however the habitat reportedly is quite artificial, and does not constitute a natural community].

The long-term effectiveness of mechanical management in creating and maintaining Karner blue habitat and overall barrens community habitat is unknown. Research in this area is badly needed.

Possible Outcomes of Mechanical Management

Positive

- *Expect significantly lower mortality of Karner blue and other invertebrate fauna* than that resulting from burn management, provided adherence to required guidelines outlined below.

- Removal or control of woody vegetation (may be more effective than fire for many woody species, especially combined with other disturbance techniques)

- Appears to maintain abundant lupine *(with proper timing; see "Mowing" guidelines, below)*

- Increased flowering of lupine and other nectaring plants *(with proper timing; see "Mowing" guidelines, below)*

- Increased seed germination and seedling establishment *(with proper timing; see "Mowing" guidelines, below)*

- Likely to involve soil disturbances that open ground for lupine and nectar plant colonization

- Reduces fuel load so subsequent fires are not as severe (clipped vegetation will decompose more rapidly than standing dead vegetation or "thatch")

- Greater niche diversity than in recently burned areas (duff and short vegetation remain)

- Less potential for erosion expected than on recently burned areas

Negative (or Neutral)

- Leaving clipped vegetation (which may contain Karner eggs) after mowing will reduce the effects produced by bare ground and increased soil temperatures compared to burning *(see "Mowing" guidelines, below)*

- Heavy machinery will disturb and compact soil, and may result in the invasion of exotics. Caution must be used to avoid spreading seeds of weedy plants via equipment as it moves from site to site.

- Waiting until early fall may reduce effectiveness in controlling or suppressing woody brush and will not control Eurasian cool-season grasses *(see "Mowing" guidelines, below)*

- Effects on lupine germination and seedling establishment are unknown

- Mowing during the growing season will negatively impact some plants and animals (like fire, this will vary with timing of treatment)

- Mowing in late summer before the end of August may remove necessary second flight nectar plants for Karner populations in some areas (e.g. roadside habitats within a forested landscape)

Because mechanical management is believed, at least in the short term, to result in lower mortality of Karner blues and other faunal components of the community than does prescribed fire, it should be strongly considered as an alternative or a complement to fire management. *Monitoring the results of mechanical management will be extremely important in helping to increase the knowledge base about its effects, both positive and negative, on Karner blue habitat.*

Mowing Requirements

A. Set blade height no lower than 6-8 inches to avoid the many eggs that will have been deposited on vegetation below that level. The blade may be set lower (4-6 inches) in portions of sites where lupine growth is held back by thatch or litter buildup and the Karner population on site is not at risk.

B. Mow no more frequently than once per year.

C. Divide occupied habitat into at least 2 units each of which supports lupine and nectar sources for adults during both flight periods. See “Expansion of Habitat through Plantings” below. Leave at least one management unit untreated each season.

D. Mow lupine areas no sooner than September 1, once all second-flight females have laid their eggs and died.

E. Let clipped vegetation remain where it falls, as it will likely contain eggs. Clippings may be collected and deposited in another site that supports lupine.

Recommendations

A. Timing: Optimal timing will vary according to habitat needs. Mowing after first frost will allow plants flowering in late summer to serve as nectar sources, complete their annual cycles and set seed. However, fall mowing will have little effect on Eurasian grasses and may have reduced effect on woody brush encroachment.

Mowing from July through early August may be considered for occasional use, as this may be the best time for controlling woody vegetation (*Please document results!*). Do not mow all management units during this time, however, nor units at high risk of losing Karners due to low numbers or isolation.

Unless justified by expected overall habitat benefits, do *not* mow lupine areas prior to seed set, the time when the pods have released the seed, which is usually completed by mid-July. If such early mowing is applied in a given year, refrain from mowing prior to lupine seed set for at least 2 subsequent years.

[Caution: Deer and woodchuck herbivory on lupine, especially on the flowering stalks, can be severe. If this is a recurrent problem, use caution in mowing prior to lupine seed set, as lupine recruitment may already be very low.]

Note the locations of lupine and nectar patches and consider addressing invasive plant management at separate times within each management unit, e.g. late June mowing of late season nectar areas.

B. If possible, use light equipment likely to have the least impact on the vegetation and Karner blue eggs.

C. If possible use a sickle mower operated from the roadside (non-lupine area), at least periodically, which will have less destructive impact on the vegetation and harbored eggs.

D. When brushing woody growth, if there is a lot of material, remove the slash from the cut area, put in piles no greater than 2 feet high, or chip it (so it doesn't cover lots of lupine. Minimize harm to the butterflies by cutting in the winter.

E. Tree or brush cutting, tree planting, and site scarification including rotovating, discing,

and bulldozing are discussed in the "Forest Management Guidelines for the Karner Blue Butterfly" developed by Cynthia Lane at the University of Minnesota, St. Paul, MN. and available from the Service's Green Bay field office.

Pesticide Use

Pesticide use on and adjacent to lands with Karner blue populations will follow the guidelines being developed by Wisconsin's Department of Agriculture, Trade and Consumer Protection (DATCP), which has been charged by the Environmental Protection Agency with developing specific guidelines to protect federally listed species and their habitats in Wisconsin from pesticide injury. These guidelines will be available from DATCP and will be incorporated into the Appendices of the Wisconsin Statewide HCP for the Karner blue butterfly.

Property managers can contact DATCP for assistance in developing a pesticide-use agreement in conformance with existing guidelines. If managers believe use of pesticides by their private landowner neighbors may adversely affect Karner blues on their land or state land, WI DNR's landowner contact specialist can be requested to visit the landowner and determine whether a pesticide risk exists. If pesticide use may impact the Karner blue, the DATCP representative will be advised and subsequently contact the landowner to explore development of a pesticide-use agreement.

Generally, it is expected that no insecticides, or broadcast applications of herbicides will be allowed in a Karner blue area of occurrence. Some selective treatment of woody vegetation and exotics with selected herbicides may be allowed. Wick application of herbicides as a tool may also be allowed.

Expansion of Habitat Through Plantings

In some cases, it may be desirable to expand areas of habitat through plantings of lupine and nectaring forbs, or to enhance existing areas with such plantings.

Requirements

A. Obtain seed from a local source or from the state native seed farm, if locally obtained. Do not plant seed obtained from an area greater than 50 miles from a destination site. Propagation and planting guidelines are available from WI. DNR Bureau of Endangered Resources.

B. Collection of lupine seed requires permission of the public property manager or private landowner.

C. *If a Karner blue population occurs at a lupine site, a federal permit will be required to*

collect seed. Consult with the Bureau of Endangered Resources to determine whether or not a lupine area supports Karners, and for assistance in identifying land managers or landowners.

D. Never harvest more than 10-25 percent of available seed for lupine or other native plants.

Recommendations

Consult a reference for nectar plant species used by Karners when planning the composition of a planting. Karners require adequate nectar plants during both flight periods as well as wild lupine. Many sites support abundant lupine, but few nectar plants. This may be especially problematic during the summer flight (July and August). *See the table "Nectar Plant Species used by the Karner Blue Butterfly" in the Appendix. A more comprehensive list of nectar plants used rangewide by the Karner blue can be found in the March, 1997 "Working Draft" Recovery Plan.*

[Take care to plant only native plant species, such as those listed in the table.]

6. Compatible Uses of Karner Blue Habitat

A federal "incidental take" permit will be needed to allow activities such as hiking, ATV use, hunting, berry picking, etc. in occupied lupine areas that are likely to result in some trampling of lupine plants and thus possibly crush or harm Karner blue eggs, larvae, or pupae. Guidelines for minimizing harm to KBBs from these activities are anticipated to be incorporated into the Wisconsin Statewide Habitat Conservation Plan for the Karner Blue Butterfly. Where an activity will not impact an occupied wild lupine area, no permit is required.

7. Contact Persons for Karner Blue Information

For information on Karner blue occurrences, distribution, biology, monitoring, or management (especially for DNR properties), or for written materials and photos for Karner Blue identification:

Kathryn Kirk
Butterfly and Moth Program Coordinator
Bureau of Endangered Resources
Wisconsin Department of Natural Resources
P.O. Box 7921, Madison, WI 53707 phone: 608/266-0545

For information on federal law and permits, projects involving federal lands or funding, Karner blue recovery planning, or general questions on Karner blue biology and management:

Cathy Carnes
Endangered Species Coordinator
U.S. Fish & Wildlife Service
1015 Challenger Ct., Green Bay, WI 54311 phone: 920/433-3803

For information on the Wisconsin DNR's private landowner contact program for the Karner blue:

David Kopitzke
Landowner Specialist
Bureau of Endangered Resources
Wisconsin Department of Natural Resources
P.O. Box 7921, Madison, WI 53707 phone: 608/264-6039

For information on the Wisconsin Dept. of Agriculture, Trade and Consumer Protection's (DATCP) Pesticides Program for the Karner blue, or particular questions about the use of certain pesticides:

Ursula Petersen
Endangered Species Program
WI DATCP
801 W. Badger Rd., Madison, WI 53707 phone: 608/266-1668

Appendix I. General Survey Information and Conditions for the Karner Blue Butterfly

Introduction: Life History of the Karner Blue Butterfly

The Karner blue completes two generations, or broods, each year. The phenology of its developmental stages varies from site to site and according to seasonal weather conditions. During a typical year, spring-brood larvae hatch from overwintering eggs in mid-to-late April and begin feeding on the new spring growth of wild lupine (*Lupinus perennis*)—the butterfly's sole larval food plant. Larvae develop and pupate among the lupines until late May, when adults begin to emerge. Males generally emerge earlier than females. The spring adult flight continues through mid-to-late June. During this time, adult females oviposit on lupine leaves, petioles, and flowering stems (often near the base).

Eggs typically hatch in about 7-10 days, and the summer (second-brood) larvae begin feeding on wild lupine leaves and flowers. Young larvae leave tiny, circular holes in the leaflets surrounding the center of the leaf. Older larvae typically eat both the upper and lower epidermis of the leaflets, which leaves behind translucent "window panes" on either side of the main vein. Although this form of feeding damage is characteristic of Karners, it is not exclusive to Karner larvae. Karner larvae feed throughout May, and again from about mid-June through mid-to-late July. Their feeding damage is more prevalent during June and early July as the second generation is usually more abundant. But it becomes difficult to distinguish the feeding damage from other damage as the season wears on into late July and August, as the plants age, dry up, succumb to fungal blights, etc. Second-brood larvae mature within three or four weeks, then pupate attached to the lupine plants, or in sheltered places among organic litter or grass.

Like many other members of its family (Lycaenidae), the Karner blue larvae have a mutualistic association with ants. Ants of numerous species can often be found collecting the liquid honeydew solution secreted by special organs on the back of the larvae. Survival of larvae to pupal stage is higher for those with ant associates. The ants are believed to protect the caterpillars from arthropodal predators.

Second-brood adults typically begin flying in mid-to-late July and continue through mid-to-late August, The summer brood size often is estimated to be three to four times greater than the spring brood, though seasonal variations may affect numbers dramatically. Summer-flight females reportedly oviposit on dried lupine pods, flowering stems, grasses, and organic litter near lupine plants where the eggs will overwinter.

Individual Karner adults are believed to live an average of only 4-5 days in the wild (males may live 6-7 days). Adult obtain the nourishment needed to reproduce primarily from flower nectar, however they have been observed sipping from moist earth, human skin, and animal droppings. A variety of nectaring plants are used. The table "Nectar Plant Species used by the Karner Blue Butterfly" is available from WI.DNR Bureau of Endangered Resources.

Like many other Lycaenids, the Karner blue has very low vagility—the characteristic distance between an individual's point of birth and point of reproduction. Based on dispersal data and observations available, researchers believe that adult dispersal can occur over a distance of up to two miles, depending on intervening habitat, however most dispersal by females occurs within 400 meters. Males are most often the ones found farther afield. Wind may carry adults over open areas. However, most adults are sedentary and do not stray far from their home lupine patch. One study has found that only 2.4 percent of all adults dispersed to other lupine areas, often along open corridors such as power lines and dirt roads.

Butterfly Surveys and Habitat Evaluation

Wild lupine (*Lupinus perennis*) is a perennial plant growing on sandy substrate which puts up new spring growth beginning in about late April, and produces very visible, showy stalks of pea-like purplish-blue flowers during May and June. In some areas flowering may continue in July. By late summer and autumn, however, the above-ground parts may die back and not be visible.

Protocol for evaluation of Karner blue butterfly habitat is presented in "Karner Blue Butterfly Habitat Evaluation Protocol". An adequate habitat assessment will include some means of characterizing the lupine density and coverage and mapping of both lupine and nectar plants. Estimates of relative abundance of different nectar plants within the habitat and flowering times will be helpful to identify energy sources available for both broods of adults. Additional habitat parameters to note as time permits are:

- Non-nectar herbaceous plants (dominants)
  Estimate relative abundance of dominant, herbaceous non-nectar species, e.g., Pennsylvania sedge, sweet fern, grasses, bracken fern

- Woody plants
  Estimate relative abundance of woody growth (Hill's oak, hazel brush, jack pine, etc.) and if possible, note average percent canopy cover, encroachment threats, etc.

- Degree of disturbance/degradation
  Note degree of native vs. non-native vegetation; presence of nuisance exotics, e.g. leafy spurge, spotted knapweed, overall quality of the site.

- Management underway or needed. Other current uses of the land, e.g. ATV trail, hiking,

forestry landing, etc. Land-use history (if known)

- Overall size (or potential size) of total barrens area, including those lands without lupine

There are two Karner blue adult flight periods per year. The first flight is from late May through mid-to-late June and the second flight from mid-July through mid-to-late August. Flight periods will vary by as much as 2-3 weeks from year to year, depending on weather. At the start of the adult flight, more males than females will be observed (Males generally emerge earlier than females.), and most individuals will appear very fresh (vivid colors, no wing damage, etc.). Toward the middle, or peak of the adult flight, the sex ratio will be about 1:1, and toward the end, more females will be observed and most adults will appear quite worn.

Proper Conditions for Butterfly Surveys

Time: Counts should be conducted between 9:00 a.m. and 6:00 p.m. During the hottest midday hours (11:00 a.m. to 2:30 p.m.), adults may become very active and perch less often, making identification and sexing more difficult.

Temperature: Butterflies like warm, sunny conditions. Counts should be conducted when the temperature is above 55 F. If the temperature is between 55 F. and 65 F., conduct counts only under mostly sunny skies when the winds are relatively calm. Counts may be conducted under cloudy skies if the temperature is above 65 F. Avoid counting during drizzly conditions (if this can't be avoided, light warm drizzle may still result in adequate butterfly observations). Do not survey for adults in heavy drizzle or rain.

Wind Speed: Adults will become less active under windy conditions. Try to survey only when winds are less than 18-20 mph. The following wind-speed indicators may be used:

Wind Speed (mph)	Indicator
< 1	Smoke rises vertically
1-3	Wind direction shown by smoke drift
4-7	Wind felt on face; leaves rustle
8-12	Leaves and small twigs in constant motion; wind extends light flag
13-18	Wind raises dust and loose paper; small branches sway
19-24	Small trees in leaf begin to sway; crested waves form on lakes

Presence/Absence Survey

The survey to establish presence or absence of Karners should be conducted as near as possible to the peak of the flight when numbers are highest. Although presence may be established by observation of an adult butterfly during either flight period, absence may only be determined with a high probability of accuracy by surveying during the second flight when the numbers are highest. Presence may also be established by observation of a larva with adequate documentation or verification by a specialist. Larval feeding damage on lupine plants may or may not be attributable to Karner blue butterflies and is not acceptable alone for establishment of Karner blue butterfly presence on a site. Detailed presence/absence survey protocol is presented in "Karner Blue Butterfly Survey Protocol - Presence/Absence Surveys" available from WI. DNR. Bureau of Endangered Resources.

Butterfly Relative Abundance

The transect count method is used to estimate butterfly numbers on a site. The method estimates relative abundance of butterflies over time for a given site, NOT to compare between sites. Refer to the protocol established by the Karner Blue Butterfly Wisconsin Habitat Conservation Plan for relative abundance survey protocol available from the WI. DNR Bureau of Endangered Resources.

Documentation

Document butterfly survey results with photographs, drawings, or detailed notes describing appearance of adults (undersides of wings are important), or close-up photographs of larvae. Collecting, netting, or harassing of any life stage of Karner blue butterflies is considered "taking" and is not permitted without federal permit nor is disturbance of the butterfly's habitat.

Associated Species

Twenty-two *rare* species highly associated with the barrens community supporting Karner blue butterflies, including nine butterflies and one moth, occur in Karner range in Wisconsin. Additional occurrence information is needed on the Lepidopteran species, several of which are less common in the state of Wisconsin than is the Karner blue. The reports "The Karner Blue Community: Understanding and Protecting Associated Rare Species of the Barrens" by Kathryn Kirk, and "Karner Blue Management Implications for Some Associated Lepidoptera of Wisconsin Barrens" by Robert J. Borth, describe these species and are available from WI.DNR Endangered Resources. *Report occurrence information to Natural Heritage Inventory, Bureau of Endangered Resources, Wisconsin DNR, PO Box 7921, Madison, WI 53707.*

Protection of State-listed Species

Some species associated with jack pine/oak barrens are listed as Endangered or Threatened in Wisconsin. The Natural Heritage Inventory maintains a list of these species. Be aware that under WI.Statute, 29.415, "taking" of any state-listed animal is prohibited without a take permit. The "taking" of any listed plant on public land is prohibited, with exemptions for forestry, agriculture, or utility projects. Scientific take permits may be granted by WI.DNR for taking of endangered or threatened species when associated with surveys or research such as collection of voucher specimens. Contact Irene Schmidt (608-267-0281) for scientific permit applications. For the taking of species that is incidental, and not the purpose of an otherwise lawful act, an incidental take permit is required. Contact Cathy Bleser (608-266-8736) or Randy Jurewicz (608-267-7507) for more information on the incidental take process. Finally, any action leading to the taking or significant impact on any plant, animal, or natural feature on a Wisconsin State Natural Area requires a Natural Area permit available from Thomas Meyer (608-266-0394).

Appendix II. Recommendations for Conducting Wild Lupine Surveys

Purpose: To find/map wild lupine (*Lupinus perennis*) patches to expedite future Karner blue butterfly (*Lycaeides melissa samuelis*) surveys.

When To Survey:

- In places where lupine flowers early (sunny areas), survey from late May to mid-June. In places where lupine flowers rarely or not at all(usually more shaded areas), surveys can be conducted from late May through July.

- Open and sunny places should be surveyed earlier in the season because lupine flowers and senesces earlier there.

- Areas with more shading and canopy cover can be surveyed later because lupine flowers and senesces later in these locations (except during hot and droughty summers).

- Lupine surveys should not be conducted after July 31.

How To Survey: An individual who is knowledgeable in the identification of lupine should conduct the surveys (lupine photos can be obtained from WDNR Bureau of Endangered Resources). Surveys for lupine can be conducted in numerous ways. The following are suggested methods to use. The method chosen will normally depend upon the amount of resources available (number of personnel) and the amount of area to be surveyed.

- OPTION 1: Surveyors walk a site spaced so all areas between surveyors can be seen by at least one surveyor. Thus, each surveyor walks a "strip transect" because a strip or corridor of habitat is being surveyed. The distance between surveyors will depend upon visibility of lupine (flowering or not), density of vegetation, and the slope of the site.

- OPTION 2: Surveyors walk a site spaced a pre-determined distance apart (i.e. 50 feet, 100 feet, etc.). Each surveyor will be conducting a strip transect. Depending upon the distance between surveyors and density of vegetation, not all areas will be observed by a surveyor (a percentage of a site will be surveyed). The distance between surveyors will depend upon the amount of area to be surveyed in the time available.

- OPTION 3: Random Walk Survey for a specified time (5 minutes) that produces a description of what was found and an estimated % coverage of habitat by the survey.

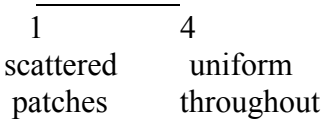
Mapping Lupine Patches: Boundaries of lupine patches should be mapped as accurately as possible. This will assist in conducting future KBB surveys.

- When mapping lupine, it may be useful to characterize each site by relative abundance and pattern of lupine distribution. Options for accomplishing these are listed below but are not mandatory:

  - OPTION A:
    - Relative Abundance (estimate)
      - A (Abundant): the dominant groundlayer vegetation
      - LA (Locally Abundant): abundant in patches
      - C (Common): frequently encountered
      - O (Occasional): infrequently encountered
      - R (Rare): very few plants seen

  - OPTION B:
    - Estimated No. of Lupine Plants or Clumps
      - 10's
      - 100's
      - 1,000's
      - 10,000+
      - 100,000+

  - OPTION C:
    - Pattern of Lupine Distribution
      - Continuum from 1-4, with 1 = very scattered patches, to 4 = uniform throughout



      - An estimate on the area of lupine coverage should be made. It is important to know if there are 10,000+ lupine plants in a one acre area versus a 10 acre area.

Low Potential Survey Areas: Since it will be impossible for most partners to survey all land holdings in 1995, the following list of low potential survey areas is provided:

- wetlands, or areas flooded for most of the growing season

- *forests with dense canopy (>75%), which could be determined by aerial photo interpretation of forest stands with a continuous canopy >75%, categorized as pole or saw timber sized stands having 3-prime density class

- sites on non-sandy soils

- cultivated or otherwise developed areas supporting no native vegetation

* NOTE: Lupine may occur in forests with greater than 75% canopy especially when the forest is adjacent to a lupine patch. Lupine may not flower in such areas and thus may be difficult to detect.

Auditing: Recommend written documentation by the surveyor on who did what, when, and where. This is important since various survey methods will be used. This requires either a standardized form or standardized requirements for what information must be reported.

For information or identification of lupine contact:

Department of Natural Resources
Bureau of Endangered Resources
ATTN: Kathryn Kirk
101 South Webster St. Box 7921
Madison, Wisconsin 53707-7921
(608) 266-0545 E-mail: kirkk@dnr.state.wi.us

Appendix III. KBB Survey Protocol - Presence/Absence Surveys

The following are *suggested minimum requirements* for conducting Karner blue butterfly (*Lycaeides melissa samuelis*) presence and/or absence surveys. For the purpose of this survey, *absence* means that KBBs were not detected at a particular site. It is not a 100% guarantee that KBBs do not exist at the site.

Purpose: To determine if KBBs occupy a particular habitat area (lupine and surrounding nectar species).

When To Survey:

- Surveys for the KBB can be conducted during both the first or second flight periods. The first flight normally begins in late May and ends in mid to late June while the second flight normally begins in mid-July and ends in mid to late August.

- Timing of flight periods can vary by as much as 2-3 weeks from year to year and/or from site to site.

- The length of flight periods may also vary from year to year (two weeks to five weeks in length).

- If resources do not allow you to conduct surveys during both flights, priority should be placed on conducting surveys during the main second flight (see "Determination of NO KBBs" listed below).

- Survey *three* times during the main second flight period. Only one survey is needed if KBBs are detected during the first survey. If you do not detect KBBs during the first survey, a second survey should be conducted. If KBBs are not detected during the second survey, a third survey should be conducted. Surveys should be spaced so that there is a 3-7 day interval between surveys.

- Conduct surveys during optimal time and weather conditions as listed below:
  - between 8:00 a.m. and 6:00 p.m.
  - when temperatures are above 60^0F
  - when temperatures are between 60^0F and 70^0F surveys should only be conducted under mostly sunny skies with calm to light wind
  - when temperatures are above 70^0F, no restrictions on cloud cover
  - when winds are less than 20 mph
  - do not survey under drizzly or rainy conditions

How To Survey: An individual who is knowledgeable in the identification of KBBs should conduct the surveys. It is recommended that individuals conducting surveys obtain training in identifying KBBs offered by Kathryn Kirk, Ann Swengel, or by WDNR entomologists or persons trained by Ms. Swengel, Ms. Kirk, or Catherine Bleser in the past. An alternative to this is having Ms.Kirk, Ms.Swengel or USFWS staff positively identify a voucher photograph. Photo must capture underside of wing for positive identification. Identification photos of KBBs may be obtained from Ms.Kirk at Wisconsin DNR.

- The KBB habitat area (lupine and associated nectar species) should be identified ahead of time when possible.

- The surveyor(s) should walk the entire habitat area at a leisurely pace until all likely locations of KBB concentration areas are surveyed.

- The purpose of the survey is fulfilled when one KBB is observed (during either the first or second flight period). It would be advantageous to spend additional time at the site to record more observations.

Intensity Of Survey:

- Approximately 10 minutes of effort per survey are recommended for each acre of habitat (i.e. lupine patches and important nectar flowers within 100 meters of the lupine patch) to determine presence/absence. If a KBB is quickly spotted, it is not necessary to spend 10 minutes per acre of habitat. Surveying for a longer period of time is encourage (but not mandatory) if KBBs are not found during the first 10 minutes of survey effort per acre of habitat.

Determination Of No KBBs:

- The determination that no KBBs are present at a site can be made once the site has been surveyed (without documenting any KBBs) three times during the second flight period of one year. Surveys should be spaced so that there is a 3-7 day interval between surveys. Note: Once one KBB is observed the purpose of the survey is fulfilled and additional surveys are not required.

General Information:

- The "Determination of No KBBs" is based on surveys during the second flight since KBBs numbers are normally significantly greater during this flight period.

- KBB flight periods vary within year from site to site depending on the site's phenology (i.e. "fast" sites and "slow" sites). Flight periods normally occur first on sunny open sites and later on shady sites. Spacing of the surveys is necessary to ensure that at least one survey is conducted during the main flight. A 3-7 day range is used because the duration and amount of suitable survey weather varies among years.

- It would be advantageous for the HCP Team to develop/coordinate a cooperative method of determining the flight period phenology each year that accounts for variation by geography an site ("fast" and "slow" sites).

- Auditing: Recommend written documentation by the surveyor on who did what, when, and where, and under what field conditions (weather, lupine condition). This will require either a standardized form or standardized requirements for what information must be reported. Recommend also that the HCP Team provide written documentation of the annual KBB phenology.

- Time Period of Effectiveness of Results: The presence/absence survey has both a spatial and temporal component (i.e. absent here now but present here later). The question - How long does the absent status apply? - will need to be addressed.

For information on identification of KBBs, contact:

Department of Natural Resources
Bureau of Endangered Resources
ATTN: Kathryn Kirk
101 South Webster St., Box 7921
Madison, Wisconsin 53707-7921
(608) 266-0545
E-mail: kirkk@dnr.state.wi.us

Appendix IV. Nectar Plant Species Used by the Karner Blue Butterfly in the Midwest

Butterflies were observed nectaring at these plants in either Wisconsin, Minnesota, Michigan, Indiana, and/or Ontario

		Seasonal Use	
Scientific Name	Common Name	First Brood	Second Brood
Herbaceous species:			
Achillea millefolium	Common Yarrow	X	X
Amorpha canescens	Lead plant		X
Anemone cylindrica	Thimbleweed	X	
Arabis lyrata	Lyre-leaved sandcress	X	X
Arenaria serpyllifolia	Thyme-leaved sandwort	X	
Asclepias syriaca	Common milkweed		X
Asclepias tuberosa	Butterflyweed		X
Asclepias verticillata	Whorled milkweed		X
Aster sp.	Aster		X
Aureolaria pedicularia	Fern-leaved false foxglove		X
Aureolaria sp.	False foxglove		X
Baptisia bracteata var. *glabrescens*	Prairie wild indigo	X	
Berteroa incana	Hoary alyssum	X	X
Campanula rotundifolia	Harebell		X
Centaurea biebersteinii	Spotted knapweed	X	X
Cerastium sp.	Chickweed	X	
Chrysanthemum leucanthemum	Ox-eye daisy	X	X
Commandra umbellata	Bastard toadflax	X	
Coreopsis lanceolata	Lance-leaved coreopsis		X
Coreopsis palmata	Stiff tickseed		X
Coreopsis sp.	Coreopsis		X
Dianthus armeria	Deptford pink		X
Erigeron strigosus	Daisy fleabane	X	X
Erigeron canadensis	Fleabane		X
Erigeron sp.	Fleabane		X
Euphorbia corollata	Flowering spurge	X	X
Euphorbia esula	Leafy spurge	X	X
Euthamia graminifolia	Grass-leaved goldenrod		X
Fragaria virginiana	Strawberry	X	
Froelichia floridana	Cottonweed		X
Galium sp.	Bedstraw		X
Geranium maculatum	Wild geranium	X	

Gnaphalium obtusifolium	Sweet everlasting		X
Hedyotis (Houstonia) longifolia	Longleaved houstonia	X	X
Helianthemum canadense	Frostweed		X
Helianthus divaricatus	Woodland sunflower		X
Helianthus occidentalis	Western sunflower		X
Helianthus sp.	Sunflower		X
Hieracium aurantiacum	Orange hawkweed	X	X
Hieracium sp.	Hawkweed	X	
Hypericum perforatum	Common St.John's wort		X
Krigia biflora	Dwarf dandelion	X	X
Lespedeza capitata	Bush clover		X
Liatris aspera	Rough blazing star		X
Liatris cylindracea	Dwarf blazing star		X
Linaria canadensis	Old-field toad flax		X
Linaria vulgaris	Butter-and-eggs		X
Lithospermum caroliniense	Hoary puccoon	X	X
Lobelia spicata	Pale-spiked lobelia		X
Lotis corniculatus	Bird's foot trefoil		X
Lupinus perennis	Wild lupine	X	X
Lysimachia sp.	Loosestrife		X
Medicago lupulina	Black medic	X	X
Medicago sativa	Alfalfa		X
Melilotus alba	White sweet clover		X
Melilotus officianalis	Yellow sweet clover	X	X
Monarda fistulosa	Wild bergamot		X
Monarda punctata	Horsemint		X
Oenothera sp.	Evening primrose		X
Pedicularis canadensis	Lousewort	X	
Petalostemon candidum	White prairie clover		X
Petalostemon purpureum	Purple prairie clover		X
Polygala polygala	Racemed milkwort		X
Phlox pilosa	Downy phlox	X	
Polygonum sp.	Knotweed		X
Potentilla recta	Rough-fruited cinquefoil	X	
Potentilla simplex	Common cinquefoil	X	X
Rosa sp.	Wild rose		X
Rudbeckia hirta	Black-eyed susan		X
Rumex acetosella	Sheep sorel	X	
Senecio pauperculus	Ragwort	X	
Senecio sp.	Ragwort	X	
Smilacena racemosa	False spikenard	X	
Smilacena stellata	Starry false Solomon's seal	X	X

Solidago ptarmicoides	Upland white aster		X
Solidago sciaphila	Cliff goldenrod	X	
Solidago speciosa	Showy goldenrod		X
Solidago sp.	Goldenrod		X
Spiraea tomentosa	Meadowsweet		X
Talinum rugospermum	Fameflower		X
Tephrosia virginiana	Goat's rue		X
Tradescantia virginiana	Spiderwort		X
Trifolium arvense	Rabbit-foot clover		X
Trifolium hybridum	Alsike clover	X	X
Trifolium pratense	Red clover	X	X
Trifolium repens	White clover	X	X
Viccia villosa	Hairy vetch	X	X
Viola pedata	Bird foot violet	X	
Zizia aurea	Golden Alexanders	X	
Woody species:			
Amelanchier sp.	Juneberry	X	
Ceanothus americanum	New Jersey tea		X
Ceanothus herbaceus	Red root	X	X
Ceanothus sp.	New Jersey tea	X	
Physocarpus opulifolius	Common ninebark	X	
Rubus allegheniensis	Blackberry	X	
Rubus flagellaris	Dewberry	X	
Rubus sp.	Bramble	X	
Salix humilis	Prairie willow	X	
Vitis riparia	River grape	X	

Scientific names follow Ownby and Morley (1991) *Vascular Plants of Minnesota: A Checklist and Atlas*, Univ. Minnesota Press, Minneapolis.

Appendix V. Karner Blue Butterfly Habitat Evaluation Protocol

1. Preliminary survey, mapping and establishment of transects for butterfly monitoring

Preliminary mapping

- Conduct a preliminary walk-through survey to determine extent of lupine and nectar sources.
- A single habitat area should be delineated as the area containing lupine and areas of nectar within 100 m of lupine. Patches of lupine separated by more than 200 m with little nectar between them should be considered different habitat areas and sampled separately.
- Pace boundaries of the area with a compass to roughly determine its size and orientation. Consult a topographic map and aerial photograph to help orient yourself.
- Sketch a map of area showing major habitat type divisions (i.e., open versus shrubby or wooded areas, dense lupine or nectar patches, etc.).

Transect Location

- Establish a baseline which is perpendicular to the longest boundary of the unit (so that transects can be as long as possible).
- Randomly locate a transect by numbering each meter along the baseline, selecting a number at random (using a random numbers table, the random number function on a calculator, etc.) and locating the transect perpendicular to the baseline at that point.
- Locate the remaining transects parallel to the first at regular intervals (20 m intervals are suggested but wider intervals may be necessary at large sites).
- Pace off transects using a compass, and mark transects at 25 m intervals using pin flags or ribbon flagging. Number each interval and record the transects and numbered intervals on a site map.

Butterfly surveys

- Conduct Karner blue butterfly surveys along the transects, noting the transect interval and perpendicular distance from the transect for each butterfly. You will obtain butterfly relative abundance along each 25-m transect interval, which can later be related to habitat data also collected along the transects.

2. Habitat Evaluation

Plot location

- Determine time available for habitat monitoring and the number of plots that can be completed in that time, assuming approximately 10 minutes per plot (10 quadrats per plot).
- Randomly select the determined number of 25-m transect intervals for location of habitat sampling plots.
- If possible, sampling plots should be distributed through all general habitat types at the site, regardless of butterfly abundance, so that future changes in habitat distribution can be detected.

Locating permanent quadrats

- Within each 25-m interval to be sampled, stretch a 10-m rope along the transect, with the midpoint of the rope at the midpoint of the 25-m interval.
- The rope should be coarse and resistant to stretching (not nylon) and marked at one meter intervals with electrical or duct tape, beginning at 0.5 m from one end (Fig. 5).
- Since quadrats will be permanent, mark the ends of the rope by driving an 18[length 1/2[steel rebar into the ground so that it protrudes 6[from the ground.

Sampling permanent quadrats

- Locate a 0.5 X 1 m quadrat (Fig. 6) at the first tape mark on the rope.
- Count the number of lupine stems, lupine flowering stems, and flowering nectar stems by species, and estimate the percent cover of ground shrubs and shade shrubs in the quadrat (note: if more than one researcher is involved in shrub estimation at a site, either during the same year or in successive years, researchers should spend time comparing methods and estimates to lessen inter-observer variablity).
- Also record the dominant ground cover within the plot (the type of cover which is most abundant, in categories of grass/carex, forb, shrub, litter, moss/lichen, and sand).
- Repeat this procedure at each tape mark on alternating sides of the transect.
- After sampling the quadrats, record any currently flowering nectar species which occur within 5 m of the 25-m interval of transect and were not recorded in the quadrats, and estimate the number of flowering stems.
- Record the slope and aspect of each 25-m transect interval.
- *Note:* it is probably not necessary to sample lupine and nectar species every year. Possibly sites could be sampled every other year. Sampling should be done during the butterfly flight period. I recommend sampling during the second brood for the majority of sites, because butterflies are generally more abundant and second brood nectar availability may be a limiting factor for Karner blue butterfly populations.

Appendix VI. Pollard-Yates Butterfly Monitoring Method

(Summary of the Wisconsin DNR's Adaptation of P-Y for Karner blue butterfly)

Objective: Monitor changes in relative abundance of KBB within a given site over time. (Can be used for other Leps. present). Provides an index of relative abundance per unit surveyed.

[One can derive an index of population trends over large geographical areas, with repeated routes at the same sites over time, using analysis techniques such as route regression (used for breeding bird roadside survey data) or ratio estimates (used for butterflies in Gr. Britain). See King and Brown & Boyce for descriptions.]

Method:

Pre-Survey Work

1) Evaluate KBB use of habitat (lupine/nectar concentrations and corresponding KBB concentration areas) to determine survey route that will maximize no. KBB you'll observe (Modification of P-Y for KBB).

   Determine number and boundaries of habitat sub-units if present (e.g., changes in management/burn units, changes from open prairie to semi-open savanna, or from ROW opening to forest edge).

2) Scope status of flight and aim for peak flight to extent possible (Can be done via networking with others, checking site throughout early flight period, checking sex-ratio, which is about 1:1 at peak, but OBSERVED ratio usually about 1.5:1 favoring more active males)

Survey Work

3) When near peak, walk route targeting high KBB usage areas. Route may be linear, circular, or zig-zagging depending on site. (CB usually zig-zags throughout lupine/nectar areas at 10-20 meter intervals depending on the size of the site).

4) Walk at leisurely pace and record # KBBs seen in box 2m to front and each side of observer (6.5 ft). (Experienced counters will also record behavior at time first observed)

5) Stopping to accurately ID KBBs is fine and often necessary!

6) ALSO record # other blues seen (e.g., E. Tailed Blues which are easily mistaken for KBB)

7) Record: Start/End time, temp., % cloud cover, approx. wind speed.

   Record size (hectares) of total site and ea. sub-unit, and approx. size of flight area for site and sub-unit.

8) Repeat for each sub-unit.

Conditions for Method:

1) Work same brood from year to year. (Spring flight can be done concurrently with lupine surveys; Summer flight often larger)

2) Aim to use same person per site per year.

3) Keep route as consistent as possible, but needn't maintain fixed route as habitat/KBB use changes.

4) Conduct between 9:30 a.m. and 5:00 p.m. During hot mid-day hours, KBBs may be so active ID is difficult.

5) Conduct only when temp. above 56 F. If between 56 F and 65 F, do only under sunny, calm conditions. If more than 65 F, may do under overcast conditions. None in drizzle or rain.

6) Conduct when winds less than approx. 18-20 mph (se wind speed indicator in BER form).

Recommendations

Works best when use 2 people: 1 observer/flusher in front, and 1 recorder/secondary observer about 10 ft. behind.

If time, pace off length of survey route in km (L) and record it so that relative sampling effort can be determined, and so units of different size can be compared (per Thomas, 1983):

To calculate INDEX per site or sub-unit: $P = (N/L) \times A$

P = KBB pop. index, N = number KBBs counted, L = length transect, and A = area of used habitat

So, if a 30 hectare site has 9 hectares of used habitat, within which 210 KBBs were counted along 3 km walked, the Population Index is 210/3 x 9 = 630

Pollard-Yates Strengths:

Long tradition of use for butterflies; many years' PY data already available for WI to help detect long-term trends.

Calibration to Mark-Release-recapture pop. estimates has shown high correlations; Rich King's research likewise showed high correlations to MRR.

Non-intrusive (versus MRR).

Time-efficient (detects most butterflies per unit time).

In many cases, will yield larger sample sizes than line-transect method, allowing for statistical analyses of greater power per unit effort.

Does not make assumptions about percent KBBs detected on or near line, does not assume extrapolations will derive absolute population densities.

Does not require estimating distances to individuals observed.

Effective for monitoring long-term trends on fixed sites managed long-term for KBB.

Pollard-Yates Limitations:

Cannot be used for direct comparisons f population trends between sites (route selection subjective, may not represent site variability adequately and consistently from site to site).

Cannot be relied upon to scientifically demonstrate effects of management treatments (though it can supplement formal studies).

Best if conducted by same persons year after year for consistency.

For areas under management for shifting mosaic of occupied habitat, can't use PY to compare

pop. index of today's site to that of a future new site, to demonstrate no net loss or net gain of KBB population levels. Would need more objective sampling method for this strategy, e.g., fixed line transect sampling, or stratified-random P-Y sampling of suitable habitat within the population complex.

This page intentionally left blank.

C. Management Considerations for Karner Blue Butterfly on ROWs

The guidelines included here were developed by the Wisconsin DNR in consultation with HCP partners.

1. Avoiding Take (no permit required)

Until a federal permit is granted by USFWS, landowners must avoid take. "Avoid" scenarios suggested by the USFWS, as they apply to areas occupied with Karner blue butterflies:

A) Do not mow/brush for short-term
B) Winter mowing over frozen ground conditions
C) Side-mounted sickle-bar mower operated from roadside or outside of habitat area before mid-April or after August
D) For small areas: hand-held weed-wacker and hand cutting, while avoiding Karner blue butterfly-occupied lupine patches

(all 6-8 inches or higher blade height)

2. Minimizing Take and Promoting Karner Blue Habitat (permit required)

A) *Management required*: No mowing between mid-April and August 31

(Lupine up during this time and used by Karner blue butterfly)

B) *Management recommended*: Wait until October or the first hard forst to mow, at least alternate years, so late-season flowering nectar-plants can reproduce. Avoid mowing annually unless necessary.

(Adults, especially July-August generation, need late-flowering plants for nourishment)

C) What is the best blade height??

Management recommended: Set blade height at a minimum height of approximately 6 - preferably 8 inches:

\ ** Where litter and thatch buildup is inhibiting lupine and other flowering plants and mowing is meant to stimulate natural fires or grazing, set blade height lower (4-6 inches), if possible given equipment.

** Where control of woody growth (shrubs, saplings) is the main management need, keep blade height at no lower than 6-8 inches in height.

(Avoid destroying eggs; Eggs will be laid on or near lupine and remain in vegetation throughout the winter.)

D. Herbicide use: use guidelines for herbicide use in Karner blue butterfly-occupied areas (see Part D of this Appendix).

E. Vehicle use in ROWs for routine maintenance and operations: Restrict vehicle use in occupied ROWs to the period between September 1 and mid-April to the maximum extent possible.

D. Pesticide Use Guidance in or near Karner Blue Butterfly Sites

The guidelines included here were prepared by the following HCP partners and participants: Dick Berry, Wisconsin Central Ltd.; Gary Birch, Wisconsin DOT; Dave Hall, DNR; Kit Hart, The Timber Co (Georgia Pacific); Ursula Petersen, DATCP (coordinator); Shawn Puzen, Wisconsin Public Service; and Tim Wilder, Fort McCoy. These guidelines were approved in March 2000 by the HCP partners and the USFWS.

1. Justifications for Pesticide Use

The HCP partners desire to protect the Karner blue butterfly and its habitat while conducting their business. The following goals for managing forestry lands and ROWs in Karner blue butterfly occupied habitats in Wisconsin include the protection of the Karner blue butterfly from pesticide related injury.

Rights-of-Way Management: Provide safe, reliable, attractive ROWs by control of invasive and noxious weeds such as Leafy Spurge, Spotted Knapweed, and Canada Thistle, and the removal and control of woody growth that could impact facility and ROW operations, and vehicle safety.

Forestry Practices: Prepare seed beds, release young pines, practice timber stand improvement, conduct timber harvests, and enable forest regeneration, through the control of weedy and woody species.

Other Management: While these guidelines were initially prepared for the management of ROWs and forestry lands greater than 1000 acres by HCP partners, they also apply to management on or near Karner blue butterfly lands by other current or future HCP partners. The guidelines are also recommended for use by private landowners and managers of Karner blue butterfly sites. Non-partner private landowners should check with the USFWS (920-465-7440) or DNR (608-261-6451) on permit needs (if any) prior to pesticide applications on occupied Karner blue butterfly sites.

The following guidelines are designed to avoid or minimize harm to the Karner blue butterfly.

2. Required Actions

Practice site management and herbicide application in accordance with HCP strategies or with individual partner species and habitat conservation agreements (conservation agreements). Follow all pesticide label directions and warnings and Wisconsin Pesticide Law (ATCP 29, Wis. Adm. Code, and others), with special care to avoid off-target applications and drift, runoff,

leaching, and dripping. Apply under wind directions as detailed below. See also the product recommendations in Attachment A (pages F-64 - F-65).

Pre-management Considerations

Conduct lupine and Karner blue butterfly pre-management surveys as prescribed in the HCP or individual partner conservation agreements. Mark or document observed populations and patches of lupine and Karner blue butterflies.

Herbicide Applications and Alternatives

Near occupied habitat, during Karner blue butterfly's active season
(April 15 – August 31**)

1. Make aerial applications *only* when the wind is *not blowing toward* the habitat *and* allow the following non-chemical buffers*: 66 feet (20 meters) between the occupied site and the treatment site. The non-chemical buffer* width may be reduced where an adequate barrier to pesticide drift exists such as a forested area, or tree/hedgerow at least 33 feet (10 m) wide and 33 feet (10 m) high, between occupied habitat and the treatment area.

2. Make wick and other ground equipment applications only when the wind is *not blowing toward* the habitat and allow a 6 feet (2 m) non-chemical buffer between the habitat and the treatment area.

3. Avoid broadcast applications within the distance likely to carry the chemical to the closest edge of the occupied habitat when the *wind* is *blowing toward the habitat*. Use a lateral drift table, found in training manuals for commercial pesticide applicators, to calculate this distance. For example, applying droplets 100 microns in diameter from 100 feet during a 10 mph wind requires a non-chemical buffer* of 1460 feet (445 m) next to the occupied habitat. At a wind speed of 3 mph, the same situation would require a non-chemical buffer of 440 feet (134 m). The use of drift-control products and methods may allow calculation of a smaller buffer*. All such calculations must be done by a certified applicator and the rationale for any substantial adjustments documented.

4. Make spot applications on basal bark, cut stump and foliage with hand-held equipment as needed. See label for possible wind restrictions.

Near occupied habitat, during Karner blue butterfly's non-active season
(September 1** – April 14)

1. Make aerial, ground and spot applications during this time. Minimize impact on nearby nectar plants where possible.

Inside occupied habitat, during Karner blue butterfly's active season
(April 15 – August 31**)

1. Make spot applications (on basal bark, cut stems, and foliage) with hand-operated equipment only, using pesticide certified personnel or personnel working under the direction of a pesticide certified supervisor. The operator shall be trained to identify Karner blue butterflies and lupine and must avoid trampling lupine plants. Heavy equipment shall not be used inside the habitat.

Inside occupied habitat, during Karner blue butterfly's non-active season
(September 1** – April 14)

1. Make aerial applications as needed.

2. Make spot and ground applications using pesticide certified personnel or personnel working under the direction of a pesticide certified supervisor.

* Non-chemical buffers: Use larger buffers than given above if required on the product label.

** Timing: Applications may be made anytime after August 15 **if** mature lupines have senesced **and** the Karner blue butterfly's second flight period has passed. For flight information call the Karner Blue Butterfly Hotline 1-877-4KARNER (52-7637).

Monitoring/Reporting Requirements

Document lupine/Karner blue butterfly survey results; pesticide use, dosage and timing, application methods, and buffer widths (if applicable); and weather at the time of application (temperature, wind speed, and wind direction) for reporting purposes and for future use in adaptive management.

Post-Management

1. Conduct post-monitoring per the HCP or partner conservation agreements, and as appropriate to implement the HCP's adaptive management program.

2. Review pesticide information (Attachment A) and management results periodically.

3. Use records of survey results, pesticide use, dosage, timing, methods, and weather for planning the HCP's adaptive management program.

3. Recommended Actions

Implementation of these guidelines will further protect the Karner blue butterfly from potential pesticide injury.

_ Choose the management methods and the herbicides that allow for a maximum stand of lupine and Karner blue butterfly nectaring plants over time while controlling the undesired species.

_ Use Integrated Vegetation Management and non-pesticide alternatives (e.g., mowing, controlled grazing, etc.) where feasible.

_ Develop initial test plots for the use of planned herbicides away from Karner blue butterfly occupied sites.

_ Initiate seed collecting for replacement.

_ Reseed lupine, nectar plants, and other native species if these species are accidentally destroyed during site management.

_ Replace ecologically invasive, non-native vegetation with appropriate native vegetation such as lupine and nectar plants after treating a site.

_ Consider monitoring the groundwater if using soil mobile products on a large scale.

_ In key areas, or when the effect of herbicide use is uncertain, minimize lupine mortality by leaving some areas untreated.

_ Near Karner blue butterfly occupied habitat throughout the year, leave a 656 foot (200 m) buffer between the habitat and the treatment area *in addition to* the requirement that application be made only when the wind is blowing from the habitat towards the treatment area. The 200 meter buffer will protect nectar plants growing within habitat areas used by Karner blue butterflies. The majority of Karner blue butterflies range up to 200 meters from their home lupine patch.

Herbicides Used (or Likely to be Used) in Karner Blue Butterfly-occupied Habitat.

See Attachment A (pages F-64 - F-65).

Use of Fungicides, Insecticides, Etc.

Pesticide application plans for fungicides and insecticides must be submitted to the Wisconsin DATCP, the DNR, and the USFWS for review and approval. Use of *Bacillus thuringiensis* var. *kurstaki* (BT) shall be as outlined in Part H of Chapter II (Vol. I, page 178).

4. Bibliography

The following references were used in preparing the pesticide guidelines.

ATCP 29. Pesticide Use and Control. Agriculture, Trade and Consumer Protection. Wisconsin Administrative Code. Register, May 1998, No. 509.

EXTOXNET (Extension Toxicology Network). 1994. Cooperative Extension, Cornell Univ., Michigan State Univ., Oregon State Univ. and Univ. California-Davis.

Farm Chemicals Handbook '97. Meister Publishing Company, Willoughby, Ohio.

Hall, D. and T. Shockley. *Herbicides for Forest Management 1999* (updated annually). University of Wisconsin-Cooperative Ext. [UWEX No. 76].

Herbicide Handbook 1994. 1997. Weed Science Soc. America, Champaign.

Lane, C. 1997. *Forest Management Guidelines*. Unpubl. Rept. to DNR and USFWS.

Montgomery, J.H. 1993. *Agrochemicals Desk Reference*. Lewis Publishers.

Nekoosa Papers, Inc. *Integrating Conservation of the KBB into Industrial Forest Management.* Unpubl. Rept.

Petersen, U.C. 1997. *Attributes and Ecological Impacts of Herbicides Used in Sensitive Habitat Management.* Unpubl. Rept., Wisconsin DATCP.

Petersen, U.C. 1999 *Herbicide Use and Alternate Management of Rights-of-Way in Wisconsin*. Unpubl. Rept., Wisconsin DATCP.

Product Label Information.

Sucoff, E. 1998. *Effect of Exposing Eggs to Herbicides on the Development of Karner Blue Butterfly*. Unpubl. Rept. March 1, 1998. Dept. Forestry, Univ. Minnesota.

Sucoff, E. 1997. Effect of Three Herbicides on The Vegetative Growth and Flowering of Wild Lupine. Final Rept. 2nd Year Observations. Unpubl. Rept. Dec. 31, 1997. Dept. Forestry, Univ. Minnesota.

Weaver-Boos Consultants, Inc. *The Strategic Management Plan for Linear Corridors in Areas Inhabited by the Karner Blue Butterfly (*Lycaeides melissa samuelis *Nabokov)*. Unpubl. Rept. Prepared for the Linear Corridor Partners, Wisconsin HCP Team.

Wisconsin DNR and HCP Partner. *Species and Habitat Conservation Agreements*. 1999. Partners include: Alliant Energy, ANR Pipeline Co., Burnett County, Clark County, Consolidated Papers Inc., Eau Claire County, Jackson County, Johnson Timber Co. (includes Bayside Timber Co., Futurewood Corp. and Magnum Timber Corp.), Juneau County, Lakehead Pipeline Co.-Limited Partnership, Monroe County, Northern States Power Co., The Nature Conservancy, Northwestern Wisconsin Electric Co., Polk-Burnett Electric Cooperative, Thilmany Division - International Paper Co., The Timber Company/Georgia Pacific/Nekoosa Papers, Washburn County, Wausau-Mosinee

Paper Corp., Wisconsin DATCP, Wisconsin DOT, Wisconsin Gas Company, Wisconsin Public Service Corp., Wisconsin River Power Co., and Wood County.

Summary Table:Karner Blue Butterfly Pesticide Use Restrictions for HCP Partners

Inside Karner Blue Butterfly Habitat, Active Season (April 15 – August 31**)	**Inside Karner Blue Butterfly Habitat, Non-active Season** (September 1** - April 14)
1. Make spot applications only (on basal bark, cut stems, and foliage) with hand-operated equipment only, using only pesticide certified personnel or personnel under the direction of a pesticide certified supervisor. The operator shall be trained to identify Karner blue butterflies and lupine and must avoid trampling lupine plants. Heavy equipment shall not be used inside the habitat.	***PREFERRED TREATMENT TIMING*** 1. Make aerial applications as needed. 2. Make spot and ground applications using only pesticide certified or personnel under the direction of a pesticide certified supervisor.

Table continues on next page.

* Use larger buffers if the product label requires

** Applications may be made anytime after August 15 *if* mature lupines have senesced *and* the second Karner blue butterfly flight period has passed .

Summary Table: Karner Blue Butterfly Pesticide Use Restrictions for HCP Partners

Near Karner Blue Butterfly Habitat, Active Season (April 15 – August 31**)	**Near Karner Blue Butterfly Habitat, Non-Active Season** (September 1** - April 14)
1. Make aerial applications *only* when the *wind is not blowing toward* the habitat, *and* allow the following non-chemical buffers*: 66 feet (20 m) between the occupied site and the treatment site. The non-chemical buffer* width may be reduced where an adequate barrier to Karner blue butterfly dispersal exists such as a forested area, or a tree/hedgerow at least 33 feet high by 33 feet wide (10 m x 10 m) between the occupied habitat and the treatment area. 2. Make wick and other ground equipment applications *only* when the *wind is not blowing toward* the habitat *and* allow a 6 foot (2 m) non-chemical buffer between the habitat and the treatment area. 3. *Avoid* broadcast applications *within the distance likely to carry the chemica*l to the *closest edge* of the occupied habitat *when the wind is blowing toward* the occupied habitat. Use a lateral drift table, found in training manuals for commercial pesticide applicators, to calculate this distance. For example, applying 100 micron droplets from 100 feet during a 10 mph wind requires a non-chemical buffer* of 1460 feet (445 m) next to the occupied habitat. At a wind speed of 3 mph, the same situation would require a non-chemical buffer of 440 feet (134 m). The use of drift-control products and methods may allow calculation of a smaller buffer*. All calculations must be done by a certified applicator and the rationale for any substantial adjustments documented. 4. Make spot applications with hand-held equipment as needed. Check label for possible wind restrictions.	***PREFERRED TREATMENT TIMING*** 1. Make aerial, ground and spot applications during this time if possible. Minimize impact to nearby nectar plants where possible.

Attachment A: Herbicides Used (or Likely to be Used) in or near Karner Blue Butterfly Occupied Habitat

Note 1: These herbicides *must* be used according to their label *and* as noted in the "Required Actions" section in this Appendix.
Note 2: Herbicides, by product name or active ingredient, not found in this table, must be approved by the DATCP, DNR, and USFWS prior to use.

Product (active ingredient)	**Concerns**	**Benefits and Recommendations**
Accord (glyphosate)	NON-SELECTIVE	Use after mature lupine senescence.
Accord/Garlon	NON-SELECTIVE	Does not appear to impact lupine and KBB after senescence. May remove heavy sedge and woody vegetation (Sucoff). May affect KBB eggs. Use after senescence and seed maturity.
Arsenal (imazapyr)	Moderate to HIGH SOIL MOBILITY and HALF-LIFE; NONSELECTIVE	Controls clover. Avoid use.
Escort (metsulfuron methyl)	MODERATE MOBILITY; NON-SELECTIVE;	Use timing as a conservation tool.
Garlon 3a (triclopyr amine)	HIGH SOIL MOBILITY	Spares clovers and alfalfa, not vetch. Takes Canada thistle, not other noxious weeds. Use minimum amount; may be better for lupine habitat than Garlon 4 but consider the soil mobility aspect on non-target vegetation
Garlon 4 (triclopyr ester)	TOXIC TO AQUATICS	Spares weedy grasses, nutsedge. Takes Canada thistle and clovers, not alfalfa or vetch. Use for spot application .

Table continues on next page.

Attachment A: Herbicides Used (or Likely to be Used) in or near Karner Blue Butterfly Occupied Habitat, Continued.

Product (active ingredients)	**Concerns**	**Benefits and Recommendations**
Karmex (diuron)	MOD. MOBILITY; LONG HALF LIFE; NONSELECTIVE	Avoid drift and runoff to adjacent land. Use minimum necessary.
Oust (sulfometuron methyl)	Low to MODERATE SOIL MOBILITY	Kills sedges, grasses. Spares legumes, probably including lupines, also composites, others. Probably ok for broadcasting in lupine sites. Reseed associates if necessary.
Plateau (imazameth)	LONG-LIVED; HIGHLY SOIL MOBILE IN SAND; COOL SEASON GRASS INJURY	Spares some warm season grasses, legumes, selected composites. Controls leafy spurge, Canada thistle. Use minimally, only spot application if possible.
Rodeo (glyphosate)	NON-SELECTIVE	Labeled for aquatic sites.
Roundup (glyphosate)	NON-SELECTIVE	See Accord.
Solution (2,4-D)	BROADLEAF WEEDS	Low drift formulation. Spares grasses. Contain within rail bed and 8' to each side of track center.
Tordon (picloram)	HIGHLY MOBILE IN SANDY SOILS; LONG-LIVED	Controls noxious species. Spares grasses. Use only for leafy spurge, minimally, only by spot application. Monitor adjacent vegetation.
Transline (clopyralid)	HIGH SOIL MOBILITY; LONG-LIVED; KILLS LEGUMES, COMPOSITES; TOXIC TO BEES	Spares cool-season grasses. Use alternatives if possible. Monitor sites for lupine and KBB. Use sparingly and only for Canada Thistle, Spotted Knapweed.
Vantage (sethoxydim)	VERY SOLUBLE	Relatively short-lived. Spares legumes and composites.
Velpar (hexazinone)	Moderate to LONG HALF-LIFE, HIGHLY SOLUBLE, KILLS LARCH, SOME GRASSES	Spares some legumes. Pine release treatments. Avoid broadcast applications in known habitat.

The above information is subject to periodic review.

This page intentionally left blank.

E. Control of Invasive Exotic Species

Contents

* The "R" (in parentheses) indicates species that also commonly occur on roadsides and right-of-ways.

Introduction

This manual is designed to assist land managers involved in implementing the *Wisconsin Karner Blue Butterfly Habitat Conservation Plan*. The invasive plant species covered are those that are most likely to have adverse ecological impacts on Karner blue butterfly habitat. The key components that characterize Karner blue butterfly habitat are wild lupine (*Lupinus perennis*) and a variety of nectar plants which bloom throughout the Karner blue butterfly's two adult flight periods. The majority of this document was drawn from the control recommendations for wild lupine habitat-related species found in the *Wisconsin Manual of Control Recommendations for Ecologically Invasive Plants* (DNR – Bureau of Endangered Resources, 1997). Other invasive plant species were added to complement the collection. These recommendations are not mandatory requirements, but are offered as management options where their application is appropriate and consistent with HCP management guidelines and individual HCP partners' conservation strategies and conservation agreements.

These guidelines primarily refer to control methods in natural areas, but are not restricted to such areas. Native plants should be protected and encouraged to grow in urban, suburban, and rural lands, not just in protected natural areas. While designed primarily for the HCP partners, individuals involved in land management, from parks personnel and public land managers to road crews to private landowners, will find these recommendations useful in efforts to promote balanced and diverse ecological communities throughout Wisconsin, from state parks and scenic riverways to roadsides and backyards.

Invasive plants have become recognized in recent years as a major threat to the integrity of natural areas. These species have the ability to invade natural systems and proliferate, often dominating a community to the detriment and sometimes the exclusion of native species. Invasive species can alter natural ecological processes by reducing the interactions of many species to the interactions of only a few species. Introduced species may compete directly with native species for nutrients, sunlight, and space, and indirectly by altering the food web or physical environment. Invasive species may also prey on or hybridize with natives. Native species with limited population size or ecological range are particularly susceptible to displacement by aggressive exotic or translocated species. According to a 1996 report by the Nature Conservancy, invasive species have contributed to the population decline of 42 percent of threatened and endangered species in the United States. Many also pose threats to agricultural areas, urban parks, yards, and roadsides. While only a small percentage of the 4,000 estimated exotic plant species in the United States cause problems, just 79 non-native plant and animal species have already cost the United States economy $79 billion.

Precautions for Karner Blue Butterflies. When using this manual, bear in mind these very important precautions:

The pesticide prescriptions in this manual are known or believed to be effective on the listed invasive plant species. Inclusion of these pesticides does not automatically mean that they do not pose a threat to Karner blue butterflies and the necessary and desirable Karner blue butterfly habitat components. As with all control measures, proceed with caution when Karner blue butterflies are present. *For pesticide use on Karner blue butterfly occupied sites, the approved HCP Pesticide Guidelines must be applied.*

Research projects by partners to the HCP conducted in or near occupied Karner blue butterfly habitat, including those entailing pesticide applications require approval by the DNR and the USFWS's Green Bay Field Office (see page124 in the HCP).

At a minimum, *managing with consideration* of Karner blue butterflies on an occupied site is more important than the reduction of invasive exotic or native vegetation for its own sake. For the purposes of this manual, the control of invasive vegetation is not an end in itself, but the means to achieving your Karner blue butterfly and *permanency of habitat* or *shifting mosaic* habitat strategies. The control measures in this manual may have negative impacts on Karner blue butterflies and Karner blue butterfly habitat, or may actually have positive affects on Karner blue butterfly habitat. Therefore, when planning invasive vegetation control as a part of your Karner blue butterfly management strategy, ask yourself these questions:

- If Karner blues are present, what affects will treatment have on Karner blues?
- If wild lupine is present, what affects will treatment have on the lupine?
- What nectar plants are available, and being used by Karner blues?
- What affects will treatment have on the primary nectar plants you need to maintain?
- What other desirable habitat components currently exist which I want to protect or maintain, such available nectar plants throughout both brood cycles, shade trees for nursery areas, etc.
- What affects will treatment have on these other desirable components?

Purpose of Control Recommendations. Many exotic plant removal and control applications have been developed for the agricultural, horticultural, and forest industries. They have focused on the use of intensive mechanical disturbance or chemical treatments. In many natural areas where Karner blue butterflies occur, many of these applications may not be feasible or may be detrimental to the ecological integrity of the areas. These guidelines address invasive species control applications in a manner sensitive to individual species and natural communities. These recommendations are not mandatory requirements, but are offered as management options where their application is appropriate and consistent with HCP management guidelines, the HCP's adaptive management program and the partners' individual conservation strategies and species and habitat conservation agreements.

This manual summarizes the morphological characteristics, habitat requirements, life history, and possible methods of control for several common invasive plant species. A reference section is included to acknowledge sources of information and to provide a reference to the literature addressing the problem of invasive species in Wisconsin. Sources for weed control tools, organizations, and other useful information are included in this section. Recommendations included here are limited to the control of some of the more problematic invasive plant species of Wisconsin. As control information on additional invasive species becomes available, and as users request information on other problem plants, these species may be added to the manual.

Feedback from the users of this manual will assist the Bureau of Endangered Resources in updating the recommendations. Readers are encouraged to send comments, questions, or control recommendations to the following addresses:

HCP Implementation Coordinator
Bureau of Forestry
Department of Natural Resources
P.O. Box 7921
Madison, WI 53707
(608) 261-6451
(608) 266-2925 (fax)
lentzd@dnr.state.wi.us (e-mail)

Invasive Species Control Coordinator
Bureau of Endangered Resources
Department of Natural Resources
P.O. Box 7921
Madison, WI 53707
(608) 267-5066
(608) 266-2925 (fax)
kearns@dnr.state.wi.us (e-mail)

Invasive Species Defined. Most invasive species are ecological pioneers and colonizers which, once introduced, quickly establish themselves in ecologically disturbed communities. Invasive species typically displace native flora due to faster growth rates, efficient dispersal mechanisms, and tolerance of a wider range of conditions. Invasive species often lack natural predators and diseases which control populations in their native environments. As the diversity and populations of native plants decrease, so does the variety of habitats available for wildlife.

For the purposes of this manual, invasive species are described as either exotic (alien),

translocated, or opportunistic. *Exotics* are primarily European and Asian species that have been intentionally or accidentally introduced to North America. *Translocated* species are native North American species whose pre-settlement range either did not include Wisconsin, or did not include certain areas of Wisconsin in which they are now a problem. *Opportunistic* species are native colonizers which can dominate certain natural communities and decrease species diversity. Some native species, such as cattails (*Typha* spp.), have historically inhabited Wisconsin natural communities in lower numbers, but have become more widespread with increased disturbance and sedimentation in wetlands. Such situations often occur when environmental conditions change, or when natural processes are restricted or eliminated (e.g. suppression of wildfires).

Bringing the Ecosystem into Balance: An Introduction to Control Methods. Human settlement often disrupts natural cycles both in the immediate environment and in surrounding areas. Disturbance creates conditions that allow opportunistic species to invade an area. In a healthy ecosystem, natural disturbances such as fire and flooding generally keep exotic and translocated species populations in check, allowing disturbance-adapted native species to thrive. With this in mind, a manager's short-term goal should be to control the problem species, and in the long-term to restore the natural processes of the ecosystem.

For most of the species listed here, there has not been a great deal of quantitative research on effective control techniques. Recommendations are generally based on the experiments and observations of land managers. Because environmental and other conditions are variable over time and space, what works in one situation might not in another. This manual does not provide techniques guaranteed to work in every situation. The recommendations do, however, provide a range of techniques that have been *reported* to work in some situations. To determine what technique might best control an invasive plant in any given situation, individual site characteristics must be evaluated, and different techniques attempted. Monitoring results and continuing control work for several years is critical to the development of long-term control.

Eradication versus Control. In a human-dominated environment, natural areas are biological islands under constant invasion by exotic, translocated, and opportunistic species. Permanent eradication of invasive species often requires an extensive expenditure of labor and resources. The time, resources, and risks involved in invasive species control dictate the feasibility of control measures. Eradication of invasive species may be preferable, but it is rarely pragmatic as a management objective; control of invasive species populations often proves to be a more practical goal. Individuals involved in land management should aim to reduce a weed's population to a level that does not affect the integrity of the native community in question. The reduction of invasive plant populations typically will allow native vegetation to exist and thrive.

Efforts to control invasive species require patience, as often more than one season of control is necessary to achieve desired results.

Methods of Prevention and Control. Methods designed to prevent or control invasive species

are separated into four categories: cultural, biological, mechanical, and chemical. Determination of the most suitable control method will depend on several variables, including the species involved, the nature of the invasion, surrounding environmental conditions, and the management objectives for the area in question. In some instances, several control methods may be combined (e.g. cutting followed by a chemical application to inhibit resprouting).

Cultural Control: Cultural control involves the modification of human behavior both within and around the natural area. Recreational and economic land uses that contribute to the introduction and proliferation of invasive species should be discouraged. A monitoring program should be implemented to identify species invasions before they become a significant problem.

Biological Control: Biological control uses a plant's natural phytophagous (plant-eating) enemies to control the species population. Highly host-specific predators must be used in order to reduce negative impact on non-target species. Biological control insects for leafy spurge (*Euphorbia esula*), purple loosestrife (*Lythrum salicaria*), and spotted knapweed (*Centaurea maculosa*) have been released in the state on an experimental basis. Native weevils (beetles) are helping control Eurasian water milfoil (*Myriophyllum spicatum*) in many lakes.

Mechanical Control: Mechanical methods include prescribed burning, mowing, cutting, girdling, and other methods that physically remove the target species. Control methods that imitate natural processes (such as prescribed burning in a fire-adapted community) are often, but not always, preferable to other tactics. Whatever the control method, it should be tailored to fit the environment, the targeted plant species, rare plant and animal species present, and the management goals for the community. Because disturbance provides fertile ground for invasive species, it should be minimized in the control strategy.

Chemical Control: Chemical use may be justified when invasive species are severely degrading the natural community, and when effective non-chemical control methods are not known or do not adequately curb invasive species populations.

Chemicals discussed in this manual are generally not listed by brand name. Also, refer to the Karner Blue HCP Pesticide Guidelines (Part D of this Appendix) for chemicals considerate of Karner blue butterflies and wild lupine.

Post-Control Work. As most invasive species spread by seed, it is likely that viable seeds will exist in the soil after most of the mature plants are removed. Likewise, for species that spread vegetatively or resprout after cutting, new shoots are likely to emerge. In addition, new seeds may be brought into the area by hikers, wildlife, wind, or water. Control sites should be monitored several times a year to identify the need for spot treatment, preventing further

population explosions of weedy species.

Removal of invasive species often results in disturbance of the soil or large areas of bare soil where native vegetation has been displaced. In many cases it will be necessary to replant the area with native species. When seeding is completed, it may be useful to plant a short-lived cover crop such as annual rye or oats to compete with the weedy species and control erosion as the native seedlings are becoming established.

Continual Improvement. Your active participation is important in improving this manual. Document the affects of treatments and control measures—what works and why—not only on the species you are trying to control, but also negative and beneficial impacts on Karner blue butterflies, lupine, soil, and other plant and animal species that may be rare or are otherwise desirable components of Karner blue butterfly habitat. Sharing your experiences and acquired knowledge will support adaptive management and help to make this manual a more valuable resource for all.

Species of Primary Concern to Karner Blue Butterfly Habitat

Plant species listed as Primary Concern are those whose habitat requirements closely match those of wild lupine (*Lupinus perennis*) and the various nectar plants upon which the Karner blue butterfly is dependent. Karner blue habitat should be effectively monitored for the presence of these invasive species so adequate control can be administered.

Trees

Quaking (Trembling) Aspen (*Populus tremuloides*)
and
Big Tooth (Large Tooth) Aspen (*Populus grandidentata*)

Description: Both species of aspen are characterized by light, green-gray bark that becomes dark and furrowed with age. Leaves are broadly ovate in outline, and have strongly flattened petioles that make the leaves tremble even in a slight breeze. The genus *Populus* is in the willow family and, like other members of this family, has flowers and fruits arranged in catkins. Cottony hairs on the tiny seeds cause them to be carried far by the wind. Viewed from a distance, clonal stands of aspen look dome-shaped: the tallest, oldest individuals inhabit the center and the smallest, youngest shoots grow at the outer edge of the clonal stand.

Distribution and Habitat: Aspen was historically considered a "weed" species until a number of industries found a niche for its fiber. Currently, aspen is an important resource, used mainly as pulpwood for paper mills. Both species have become a concern to some land managers. Although aspens are native to Wisconsin, they are sometimes invasive because their prolific clonal growth pattern allows them to shade out herbaceous species in prairies and oak savannas.

Both species are normally found in woods and woodland edge habitats in Wisconsin, especially on cut-over or burned land. Bigtooth aspen grows from Nova Scotia to Minnesota, southward to North Carolina, and westward to Missouri. Quaking aspen inhabits a wider range, extending from Labrador to Alaska in the northern part of the continent, from New Jersey westward to Nebraska, and along the Rocky Mountains southward into Mexico.

While they are a natural part of early successional woods, aspens become a problem in prairies that have not been managed with fire for some time. Both species thrive on a wide variety of sites. Typically, quaking aspen is found in moist woods and along streams, while bigtooth aspen grows in comparatively drier soil. Both are found in young woods after disturbance and at the edges of mature woods.

Life History and Effects of Invasion: Bigtooth aspen is a gap-phase tree of importance in the

dry to mesic forests of Wisconsin. It requires soil disturbance for establishment, and is usually found in forest gaps created by fires or harvests. The ashes found on burned soil surfaces offer optimal conditions for germination. Quaking aspen is a pioneer invader following forest fires, logging, or other episodes of disturbance.

Aspen flowers in March and April, and the fruit ripens 4-6 weeks after flowering, generally from May to June. Both species produce an abundance of wind-dispersed seeds. The small seeds can be widely dispersed, but must germinate within a few days of their dispersal. Seedlings grow very quickly, often at a rate exceeding three feet per year for the first decade. Clones expand radially by sprouting 3-6 feet of shallow, horizontal roots per year, depending on the site. By the time aspen individuals are 20 to 30 years old, their canopies expand and shade out other clones in the stand, thus encouraging fungal diseases to attack the shade-intolerant trees.

Controlling Aspen

Mechanical Control: Although it is labor intensive, girdling is quite successful in clonal stands where most individuals are larger than 1" in diameter; this method is not effective on young clones that have resprouted. All stems in the clone with a diameter greater than 1" should be girdled. The girdle should be at least 2" wide around the tree to prevent the bark from bridging across the girdle. Aspens can be girdled in the spring until the time leaves reach full size in May or June. It is easiest to separate the bark from the tree at this time. The technique of girdling requires making a cut just through the bark to the outer layer of sapwood; this cut can be made with a bark spud (made from a sharpened car spring) or a crowbar. On smaller stems, a beveled butter knife may be used. Avoid using saws because they may cut too deeply, thus stimulating resprouting. After making the cut, insert a sharpened bark spud into the natural divide between the bark and the sapwood and rotate the girdling tool around the trunk to remove the bark. Leaving the sapwood intact while removing the bark allows trees to continue pulling water, nutrients, and carbohydrates up from the root system while preventing carbohydrates from traveling down the trunk to feed the roots. Thus, the roots starve slowly, and trees usually live for 1 year after girdling. Wait until trees are completely dead before removing.

Ill-timed burning or cutting of live aspen can make established clones difficult to remove. Aspen responds to stem removal by generating an imbalance of hormones in the roots to promote the formation of root sprouts or suckers. Once the clones have been put into the hormonal "suckering mode," there are no known treatments to prevent their continued production of suckers. However, aspen may be controlled by using fire in August, as later frost will kill reprouts.

Stem cutting is much less effective than girdling, but can be used as a control method. In order to avoid the formation of suckers, cutting must be timed to coincide exactly with maximum leaf-out in summer, when most resources have been translocated to stems and leaves and root resources are at their lowest. This initial cut must be followed by repeated hand cutting of sprouts in the

same growing season, or again at maximum leaf-out in subsequent growing seasons. Follow-up cuttings should be made by hand to allow the competing, shade-producing vegetation to remain standing. Ideally, the initial, well-timed cut will cause up to a 50% reduction in stem density. Cutting can be done with loppers, a chain saw, power brush cutters, or a brush hog.

Cutting can be effective if coordinated with some other mechanical control on sites other than natural areas. A large clone may have the overstory cut, followed by a leveling of the resprouts using heavy site scarification equipment. This has proven to be a cost-effective option in aspen control, but can be damaging to other vegetation in the area. Scarifiers such as roller choppers, discs, and root rakes can be used to mechanically control aspen. If possible, a single pass in July should be followed by a second pass in August (after reprouting) for optimal control. Based on field experience, multiple passes during the growing season are more effective than a single pass.

Chemical Control: Basal injections or basal bark applications of triclopyr to uncut stems are the best means of controlling aspen chemically because application is easy and injury to other species is minimal. Every stem of the clone must be treated. Some damage to surrounding vegetation should be expected with these techniques. Young suckers or cut clones can be treated with a wick application of glyphosate on the stems, although this method has not proven completely effective. The herbicide 2,4-D is also effective as a foliar application but will kill other herbaceous species.

Black Locust (*Robinia pseudoacacia*)

Description: Black locust is a deciduous tree of the legume family (Fabaceae) that grows from 30 to 80 feet tall and is often attacked by stem borers and other insects, causing deformed growth and dieback. The tree has a shallow, fibrous root system and spreads vegetatively by means of underground rhizomes. Young saplings have smooth, green bark while older trees have dark, shaggy bark marked by deep furrows and flat-topped ridges. Leaves are borne alternately on the branches, and, on younger branches, the leaf stipules may be modified into spines. Pinnately compound, the leaves are composed of 7 to 21 leaflets; each thin, elliptical leaflet is dark green above and pale beneath. Showy racemes of drooping flowers are produced in May or June, the flowers being pea-like in appearance, fragrant, and white and yellow in color. The flowers give rise to shiny, smooth, narrow seed pods, flat in cross-section and 2 to 4 inches in length; these pods each contain 4 to 8 seeds. Black locust stands are easy to identify in spring because they typically form multiple-stemmed clones and are slow to leaf out.

Distribution and Habitat: Black locust is native to the slopes and forest margins of Southern Appalachia and the Ozarks. It was introduced throughout Wisconsin in the early 1900's because its aggressive growth pattern and extensive root system discourage soil erosion. Black locust wood is valued for its durability and high fuel value, and the tree provides good forage for bees. It is frequently found in upland prairies, savannas, roadsides, old fields, and woodlots in Wisconsin. The tree prefers sandy or loamy, well-drained soils in open, sunny locations.

Life History and Effects of Invasion: Black locust produces abundant seeds, but a thick seed coat hinders consistently successful seed germination. The plant typically reproduces vegetatively by root suckering and stump sprouting. Root suckers arise spontaneously from established root systems, sprouting new shoots and interconnecting fibrous roots to form extensive, dense clones. Damage to roots or stems (e.g. from fire, wind, cutting, disease, etc.) stimulates vigorous sprouting, root suckering, and lateral spread. Black locust is susceptible to severe insect damage from locust borers, locust leaf miners, and locust twig borers.

Black locust commonly occurs in disturbed habitats like pastures, degraded woods, thickets, old fields, and roadsides. Successful reproduction via vegetative runners has contributed to the naturalization of this plant in upland forests, prairies, and savannas. Because dense clonal stands shade out most understory vegetation, black locust groves can be detrimental to native vegetation. In low nutrient soils, black locust may increase levels of soil nitrogen, thereby increasing habitat for weedy species and further eliminating natives. It is also suspected that black locust may produce allelopathic compounds, chemicals hindering the growth of other plants.

Controlling Black Locust

Mechanical Control: Cutting black locust stimulates sprouting and clonal spread; for this reason, some suggest to avoid cutting the stems. Girdling is also ineffective because it kills the stem but does not prevent sucker formation. (Cutting and girdling may be effective, however, when employed in conjunction with herbicides. See below.) Mowing and burning temporarily control spreading, but mowing seems to promote seed germination, and burning stimulates sprouting. Annual haying may be adequate to control first year seedlings and prevent spreading in prairie communities. Bulldozing may be an option on already disturbed lands.

Chemical Control: Since the extensive root system of black locust spreads herbicides over large areas, basal bark application is preferred for treatment because it is selective and easy to apply. During basal application, herbicide should be applied in a band at least 6 inches in width around the circumference of the trunk; the herbicide band should approximately 12 inches from the ground. Triclopyr formulated for dilution in horticultural mineral oil is currently the herbicide of choice for black locust. Use caution when applying this herbicide, as mineral oils release volatile organic compounds into the immediate area. The triclopyr/oil mixture may also be applied to a girdle cut at standing height or to cut stumps to control locust.

For small isolated plants or thick patches under 5 feet in height (such as those resulting from cutting or fire), fosamine ammonium can be applied as a foliar spray. Fosamine ammonium kills plants by inhibiting leaf bud growth and flower formation the following spring. Fosamine ammonium should be applied at the end of the growing season. In order to effectively curb regeneration, every branch or stem must be sprayed because missed stems will leaf out. Triclopyr

mixed with water may also be used effectively as a foliar spray in the latter half of the growing season.

Glyphosate can be applied to foliage of actively growing trees using a hand sprayer. However, foliar glyphosate spray should not be applied in high quality natural areas because it is a nonselective herbicide. A solution of glyphosate can also be applied to black locust stems cut at the base with brush-cutters, chainsaws, or hand tools. Cut-stump treatment works best when applied in late summer, early fall, or during the dormant season. This technique works better at some sites than others; experiment on a small area to determine what technique works best for your site.

Shrubs:

Smooth Sumac (*Rhus glabra*)
and
Staghorn Sumac (*Rhus typhina*)

Description: Sumac is a clonal shrub which forms a spreading crown of dense multiple stems rarely reaching over 10 feet in height. Young branches of staghorn sumac are covered with a dense growth of hairs, while those of smooth sumac are smooth and somewhat glaucous (covered with a fine, waxy, removable powder that imparts a whitish or bluish cast to the surface). Likewise, leaves are supported on hairy petioles in staghorn sumac and smooth petioles in smooth sumac. The leaves are pinnately compound with many leaflets (9-29 leaflets in staghorn sumac and 11-31 leaflets in smooth sumac); leaflets are serrate, and commonly darker on their upper surfaces and nearly white beneath. In the fall, leaves become conspicuous, as they often turn a brilliant red. At the onset of late summer, sumacs produce fruit on terminal inflorescences. Fruits, borne by female clones, are very dense clusters of tiny red drupes (fleshy fruits with a hard, stony center) covered with minute hairs; those on the fruits of staghorn sumac generally longer than those of smooth sumac. The drupes persist well into winter, and are often easy to distinguish against the backdrop of snow.

Distribution and Habitat: Smooth sumac is an opportunistic, native prairie shrub that occurs throughout the U.S. and southern Canada, although it is most abundant in the eastern U.S. This species grows in a variety of habitats, including disturbed sites such as abandoned fields, roadsides, and fence rows; it also grows in native communities such as mesic, dry-mesic, and dry upland prairies, and openings in oak forests.

Staghorn sumac, also a native species, can be found from Nova Scotia to southern Quebec to Minnesota, and south to West Virginia, with sporadic occurrences in Georgia, Alabama, and Iowa. It tends to prefer dry, open habitats.

Life History and Effects of Invasion: The sumacs can be aggressive, reproducing locally as groups of clones that spread outward by rootstocks, though, if the clones are left alone and not stimulated to spread by cutting or burning, they will die over time. Spread of sumac to new areas takes places via the distribution of seeds. The sumacs flower in late May and June, and form mature seeds by September; once seeds are dispersed to suitable habitats, the sumacs sprout easily and grow rapidly, but require direct sunlight to persist. Smooth sumac rarely grows to the size of a small tree, whereas staghorn sumac may become quite large under the right conditions. Resprouts grow rapidly and can reach 3 feet in one year.

Since sumacs are native species, the management objective is usually to keep them under control, not to eliminate them. This is especially the case with smooth sumac, which commonly overruns prairies; often when prairies are first acquired, they have not been burned for many years, allowing smooth sumac to dominate the landscape. Because smooth sumac can eliminate or reduce the abundance of many other species that cannot persist in its shadow, it should be controlled.

Controlling Sumac

With all control methods, the ENTIRE clone should be treated.

Mechanical Control: Cutting during the dormant season or prescribed burning can remove above-ground growth, but sumac will resprout vigorously. In places where dense sumac has shaded out other vegetation, there may not be enough fuel to carry a fire. Growing-season cutting has been found to be effective, and growing-season burning will also probably reduce sumac density. Double-cutting (once in July and once in August) may need to be repeated for several consecutive years to achieve effective control in dense populations. One researcher found that cutting five times over two years reduced sumac density by two-thirds. Another variant is to mow with a sickle-bar every year in mid to late July.

When sumac occurs on mesic sites, the area can first be burned in spring, promoting the production of a vegetative cover of other species. Burning should be followed by hand-cutting

of sumac stems at ground level in July and August. Sumac will resprout after each cutting, but dense vegetation may prevent sumac from receiving enough sunlight, causing the leaves to turn yellow. Eventually, the resprouts may die.

Mid-summer mowing combined with spring burns to stimulate herbaceous vegetation may effectively reduce sumac populations. Small populations may be kept under control by prescribed burning every three or four years; because rocky conditions often limit the use of tractors and power brush cutters, cutting is often done by hand with brush nippers or loppers.

Chemical Control: Herbicides are effective in eliminating smooth sumac. A stump treatment of glyphosate has proven effective in killing sumac when applied immediately after cutting during July and August. However, glyphosate is a nonselective herbicide that will kill most photosynthetically active plants when applied during the growing season. Glyphosate can be applied to freshly cut stumps using either a low-pressure, hand-held sprayer or sponge applicator.

Oil-based triclopyr herbicide is can be used for basal treatment. The entire circumference of each stem in the clone must be treated, and no cutting need be done. This can be quite time-consuming for large clones.

Foliar applications of water-based triclopyr or glyphosate also are effective. Foliar applications should only be done in areas with little or no native vegetation.

Caution: Some individuals may react negatively from contact with the juice of smooth or staghorn sumac, which can cause dermatitis (irritation of the skin). Individuals highly sensitive to poison sumac or poison ivy should wear gloves and long sleeves when cutting sumac. When working near wetlands, be careful to avoid contact with poison sumac (*Toxicodendron vernix*), a similar-looking shrub with 7-13 leaflets and grayish-white fruits.

Forbs:

Canada Thistle (*Cirsium arvense*)

Description: Canada thistle is a dioecious perennial forb with slender, grooved stems that branch only at the top; it ranges from 2 to 5 feet in height at maturity. Stems are slightly hairy when young and progressively more hairy as the plant matures. The leaves are smooth, oblong, tapering, somewhat lobed, and characterized by crinkled edges with numerous spines along the margins. Numerous and fragrant purple flowers grow to 3/4 inch in size from July to September. The small, light-brown seeds are slightly tapered and have a tuft of tan hair loosely attached at the tip to enable wind dispersal.

Distribution and Habitat: Canada thistle is native to Europe, not Canada, as its name suggests. Its current range encompasses the northern portion of the United States east of the Rocky Mountains. Canada thistle is considered a noxious weed under Wisconsin law and should not be allowed to go to seed.

Canada thistle thrives in disturbed areas and in a wide variety of soils. In undisturbed prairies or shady woodlands, the plant becomes tall and lanky with few flowers. Although a high water table limits root development, it sometimes occurs in wetlands where water levels fluctuate (such as stream banks and ditches) and in wet prairies or sedge meadows adjacent to disturbed areas. It is abundant along roadsides, and its seeds are spread by mowing after flowering has begun.

Life History and Effects of Invasion: Canada thistle is an exotic, herbaceous, clone-forming perennial. The species is found in agricultural areas throughout Wisconsin. This thistle does not pose a serious threat to high quality natural areas; however, it can greatly reduce species diversity in old fields, disturbed natural areas, or areas under restoration. It is important to control this species prior to restoration work.

The plant grows in clonal patches of solely female or solely male plants. As a result, some patches produce seeds and others do not. Seeds mature quickly and are capable of germinating within 8 to 10 days after the flowers open, even if the plants are cut when flowering. Most seeds germinate within one year, but may remain viable in the soil for up to 20 years. Seeds are dispersed by wind.

The root system of Canada thistle is usually within a foot of the ground surface, but may extend 6 feet deep or more in loose, well-tilled soil. The horizontal roots branching from the fibrous taproot of a plant can spread 10 to 12 feet in one season, resulting in a circular infestation 20 feet across. Aerial shoots are sent up in 2 to 6 inch intervals, and generally produce basal leaves the first year and flowering stems the next year.

Introduction to new areas occurs mostly by windborne seed or sometimes by water runoff. Small sections of broken roots are capable of producing new plants.

Controlling Canada Thistle

A buffer zone should be established and maintained between a natural area and external sources of thistle to prevent vegetative invasion. Plants within wind-dispersal range should be controlled prior to restoration of an area.

Mechanical Control: In a good quality natural area, routine mowing or selective cutting effectively reduces an infestation within 3 or 4 years. Use a scythe or other sharp tool for selective cutting. The ideal time to cut is in the very early bud stage when food reserves are at their lowest point. Plants cut 8 days or more after flowers have opened should be removed from the site because seeds mature quickly; thus, cutting should be completed prior to flowering and seed set if possible.

Late spring burns effectively discourage this species, whereas early spring burns can increase sprouting and reproduction. Healthy, dense prairie vegetation can produce enough competition to reduce the abundance of Canada thistle. Encouraging the development of communities with native species is the best prevention for the establishment of Canada thistle.

For light to moderate infestations, repeated pulling, hand-cutting, or mowing with a brush cutter is an option. Plants should be pulled or cut at least three times during the growing season -- for

example, in June, August, and September. Some persons have had success killing individual plants by cutting the top and pouring table salt down the hollow stem.

Dense infestations of Canada thistle on large sites other than high-quality natural areas can be controlled by mowing close to the ground while the plant is in full bloom or just before flowering. Control will take a few years. If seeds are ripe, cut flowerheads must be removed from the site immediately to avoid further seed dispersal.

Chemical Control: Control of this species with herbicides in natural areas is not recommended, as the herbicide can pose more of a threat to native vegetation than the thistle. However, spot application of the amine formulation of 2,4-D using a wick applicator or hand sprayer can control individual stems if necessary.

Infested lands that are not considered high quality natural areas may be controlled using a foliar application of glyphosate solution in spring when plants are 6-10 inches tall.

Transline® is an herbicide selective primarily for legumes and composites. It is best applied in pre- or early bud stage, but is effective even when plants are in seed. Follow label recommendations for proper application methods and concentrations.

Musk or Nodding Thistle (*Carduus nutans*)
Plumeless or Bristly Thistle (*Carduus acanthoides*)
and
Bull Thistle (*Cirsium vulgare*)

Description: Several native thistles exist in prairies that may be confused with exotic species. Verify identification before initiating control work.

Musk thistle is a large, biennial herb. Leaves are dark green, have a light-green midrib, are smooth and hairless on both sides, and are slightly wavy; leaf margins are coarsely lobed, each lobe ending in a prominent spine. First year rosette leaves can be up to 24 inches long. Stem leaves are borne alternately. The stem appears winged and is freely branched, reaching heights of two to seven feet. The terminal flower of musk thistle is large--1 1/2 to 3 inches in diameter--solitary, and usually nodding or slightly bent over.

Plumeless thistle is similar to musk thistle, but has many leaf-like spines on its stem and hair on the underside of its leaves. In addition, the red to purple flowers of plumeless thistle are much smaller--usually about one third the size of musk thistle flowers. Plumeless thistle flowers can occur singly or in clusters, are erect on the stems, usually not drooping or nodding. Musk and plumeless thistles can hybridize, and both have a very similar appearance in the rosette stage.

Bull thistle is also a biennial with prickly, winged stems. The leaves are coarse and spiny above with wooly white hairs below. In this thistle, a purple "brush" of flowers emerges from a spiny green ovoid base.

Distribution and Habitat: All of these thistles are exotics introduced from southern Europe and western Asia. Musk thistle is a particularly pervasive weed--it has been reported in 42 states and labeled a noxious weed in 16. It is especially problematic on the Great Plains and in mesic pastures of the Intermountain West.

These thistles are most commonly found in disturbed areas such as pastures, roadsides, waste areas, and ditch banks. They are also a problem in prairies, old fields, and hay fields.

Life History and Effects of Invasion: The life cycles of these species are similar. They are primarily biennial or winter annuals, but may act as annuals in areas of sparse vegetation and fertile soil. Seedlings emerge from early spring to late fall, and the length of time to flowering can vary from 4 to 22 months. A single taproot is formed, and reproduction is by seed.

Stem elongation takes place in early May. Blooming starts with the terminal head in early June and continues until mid-August with the lower branches. Seeds mature and may disperse within 7 to 10 days of flowering. The bulk of seed is produced on the upper branches, and germination may run as high as 95%. Wind dispersal allows for movement over long distances. Seeds can remain viable in the soil for over 10 years, and each plant is capable of producing up to 10,000 seeds.

These thistles typically do not pose a great threat to high quality natural areas, although they have been known to invade native and restored grasslands despite the presence of dense, native prairie vegetation. Glade communities are also likely areas for thistle establishment. These species are very aggressive in disturbed areas, and can pose a major problem in buffer zones and restoration areas. Control of these thistles is important before beginning a prairie restoration.

Controlling Exotic Thistles

A buffer strip between a preserved area and external sources of exotic thistles should be established and maintained to prevent invasion.

Mechanical Control: Eliminating seed production is the most effective mechanical control technique. Thistles mowed in bud or early bloom stage will produce new branches from buds in the axils of the basal leaves. However, close mowing or cutting twice per season will usually prevent seed production. Mowing can be done at any time during the growing season, although cutting is easier when the thistles are smaller. Mowing once flowering has begun may result in the spread of viable seeds with the mower. For effective selective control, plants should be cut with a sharp shovel at 1" to 2" below the soil surface before flowering occurs. Competition with

native vegetation decreases seedling establishment.

Chemical Control: Herbicides are not recommended for use on exotic thistles in high quality natural areas. Chemical control is most effective when plants are in the rosette stage and least effective when thistles are flowering.

On severely disturbed sites, 2,4-D ester can be applied using a backpack or tractor-mounted sprayer or in granular form. It is most effective when applied 10-14 days before bolting of the flowering stems. Dicamba can be used earlier in the spring than 2,4-D. Spring applications of dicamba in combination with 2,4-D ester have resulted in up to 97% control by the fall of the same year.

Picloram alone or in combination with the other herbicides mentioned gives the best late-season control, but is more expensive, cannot be used near groundwater or during certain seasons of the year, and presents a greater risk of damaging nontarget species. However, nontarget plants are less susceptible during the cool, dry autumn season, and picloram has been effective when applied during fall.

Transline® is an herbicide selective for legumes and composites. It is best applied in pre- or early bud stage, but is effective even when plants are in seed. Follow label recommendations for proper application methods and concentrations.

Biological Control: Two exotic weevils, the flower head weevil (*Rhinocyllus conicus*) and the rosette weevil (*Trichosirocalus horridus*) have been introduced in several states and appear to be effective biological control agents that limit populations of musk thistle. However, these insects are not in use in Wisconsin due to the risks presented to rare native thistles, which they are known to feed on.

Crown Vetch (*Coronilla varia*)

Description: Crown vetch is an herbaceous perennial legume with creeping stems 2-6 feet long and a reclining growth habit. Leaves are compound and consist of 15-25 pairs of oblong leaflets. This species has rhizomes that can grow up to ten feet long, thus contributing to rapid and extensive vegetative spread. Flower are clustered in umbels on long, extended stalks; colors range from pinkish-lavender to white. Flowering occurs from May through August, after which time long, narrow pods containing slender seeds are produced.

Distribution and Habitat: Crown vetch (also known as trailing crown vetch) is a non-native perennial frequently used as a ground cover for erosion control and as a green fertilizer crop. It is used as a bank stabilizer along roads and waterways. The plant's original habitat includes Europe,

southeast Asia and northern Africa. The plant's distribution in the U.S. encompasses most of the northern U.S. east of South Dakota.

Crown vetch has been planted extensively in the northern two-thirds of the United States on road banks and other areas prone to erosion. This plant readily escapes cultivation; it may be found invading remnant prairies, woodland edges, agricultural fields, hayfields, pastures, and the banks and gravel bars of streams. It has typically been planted along roadsides and other right-of-ways, but quickly spreads into adjacent prairies and open fields. Crown vetch prefers full sunlight, but healthy populations have been found in partial shade.

Life History and Effects of Invasion: Crown vetch is a serious management threat to natural areas due to its seeding ability and rapid vegetative spread by creeping roots. Flowers appear from May to August and produce few to several seeds. Seeds can remain dormant and viable for over fifteen years.

Controlling Crown Vetch

Very little information is currently available regarding the control of crown vetch. Research has largely been restricted to the establishment and management of this perennial legume. As a result, a limited number of control measures have been gleaned from the unpublished notes of active natural resource managers. Further field research is needed to adequately address this species. However, preventative measures can and should be implemented. Do not use crown vetch for erosion control. Encourage your local highway department to stop using it and replace it with less invasive species for roadside use.

Mechanical Methods: In fire-adapted communities, prescribed burning in late spring can be an effective control. Burns may need to be repeated for several years to achieve adequate control.

Where feasible, late spring mowing for several successive years can control this species. Another technique is to mow twice every year--in June and in late August--corresponding with successive leaf-out periods.

Chemical Control: The herbicide 2,4-D amine (dimethylamine salt of 2,4-D) is a low volatility formulation that can be foliar-applied in early spring when crown vetch is growing actively. 2,4-D amine should be applied by hand sprayer at the label-recommended application rate for spot application. Phenoxy herbicides are broadleaf-selective plant growth regulators that will not harm grasses, but precautions must be taken in the vicinity of non-target broad-leaved plants. To reduce vapor drift, use an amine rather than an ester formulation of 2,4-D.

A solution of triclopyr in water has also been successful in controlling large infestations. Like 2,4-D, triclopyr is advantageous because it is dicot-specific and does not affect grasses beyond

some temporary browning. Glyphosate is a broad-spectrum, translocated herbicide that can be foliar-applied as a solution during early spring when crown vetch is actively growing. Glyphosate is nonselective, and care should be taken to avoid non-target plants. To insure good foliar coverage, the previous year's growth should be burned to eliminate duff accumulation and to expose new growth. A follow-up application of glyphosate may be necessary the following fall or early spring to combat regeneration from underground parts or seed.

The herbicide clopyralid has been used successfully to treat roadside populations of crown vetch. This herbicide shows promise because it is even more specific than triclopyr in the plant families it affects; specifically, this herbicide kills leguminous species but does not affect grasses and most other plant families. *However, the herbicide clopyralid also has deleterious effects on lupine at all life stages; its application must be closely monitored.*

When applying any of the herbicides described above, spot applications should be done uniformly with a hand sprayer to ensure that the entire leaf is wetted. Do not spray so heavily that herbicide drips off the target species. Native plants, left unharmed, will be important in recolonizing the site after crown vetch is controlled. Reseeding of native plants may be necessary where infestations of crown vetch are severe. Planting an intermediate cover crop may be appropriate.

Transline® is an herbicide selective for legumes and composites that can be very effective in targeting crown vetch which is overtaking grass. It is best applied in pre- or early bud stage, but is effective even when plants are in seed. Follow label recommendations for proper application methods and concentrations.

All of these methods may need repeated applications over several years to effectively eradicate populations of crown vetch that are well established; thus, regular monitoring of treated areas will be necessary.

Leafy Spurge (*Euphorbia esula*)

Description: Leafy spurge is a member of the spurge family (Euphorbiaceae), ranging from 6 to 36 inches in height. The erect stems of this plant support alternate, linear, apetiolate leaves of a bluish-green hue. When in bloom, the plant bears multiple yellow-green inflorescences arranged in an umbel near the top of the stem; to the casual observer, each of these condensed inflorescences may appear to be only a single flower. The yellow-green bracts which subtend each inflorescence are the most colorful and conspicuous part of the plant. A milky white sap is present in all parts of the plant, and aids in identification, although this sap is present in all species of *Euphorbia*.

Similar Species: The related cypress spurge (*Euphorbia cyparissias*) has been found invading some dry grasslands in western Wisconsin. Control techniques are generally similar to those employed to control leafy spurge.

Distribution and Habitat: Leafy spurge is a deep-rooted Eurasian perennial that is adapted to a wide range of conditions. First recorded in the U.S. in 1827, it may have been introduced accidentally as a contaminant in agricultural seed stock or intentionally as an ornamental for its attractive bracts. The plant is not palatable to cattle and is considered a serious pest on the grasslands of the Great Plains. Leafy spurge occurs primarily in non-cropland habitats, including roadsides, prairies, savannas, and woodlands and is tolerant of a wide range of substrates, from damp to very dry soils. In Wisconsin, it is usually found in light, dry soils. Spurge prefers sunny conditions, but can also grow in savanna habitats.

Leafy spurge is considered a noxious weed under Wisconsin law, which requires landowners to attempt eradication of the species.

Life History and Effects of Invasion: Leafy spurge possesses multiple characteristics which serve to make it an aggressive competitor, spreading rapidly to crowd out desirable species. It appears that the plant is allelopathic, producing chemicals to impede the growth of competing species. It also forms hybrids readily, the hybrids of *E. escula* and other spurge species often collectively referred to by the common name "leafy spurge." The plant produces dense stands of up to 1,800 stems per square yard and has a deep root system composed of woody, tough roots which can reach depths up to 15 feet and spread laterally up to 35 feet, making eradication extremely difficult. Vegetative reproduction from both crown and root buds contributes to the persistence of the weed; even if the foliage of the plant is destroyed, the roots will regenerate new shoots.

Leafy spurge's extraordinary seed dispersal mechanisms also contribute to its success. The plant reproduces readily from seed dispersed up to 15 feet by explosive ejection from the seed capsule. Once established by seed, leafy spurge reproduces and spreads rapidly via vegetative reproduction. Shoots emerge in late March, and the plant blooms from May to the end of July, when it is most easily recognized by its yellow-green bracts. Seed development continues for up to six weeks after flowering. Leafy spurge usually ceases to grow during the hottest and driest weeks of July and August.

Leafy spurge can be catastrophic to grasslands for both economic and ecological reasons. It is estimated that the plant can reduce the productivity of grazing land by 50 to 75 percent, and it currently inhabits about three million acres of rangeland in the U.S. The species outcompetes other vegetation by shading competitors and sequestering available moisture and nutrients. In natural areas, leafy spurge reduces species diversity and habitat for wildlife, and has the ability to displace native grasses and forbs in the course of only a few years.

Controlling Leafy Spurge

Mechanical Control: In the Great Plains, much effort has been channeled towards finding a

control method for leafy spurge. Although most agree that control depends on destruction of the root system, no mechanical methods have been found to work effectively. Fire, cultivation, obscuring sunlight, and mowing have not been successful. Hand-pulling, digging, and tilling are only successful if the entire root system can be excavated and may increase the number of plants if root remnants remain in the soil.

Biological Control: Several biological control agents are being investigated (flies, beetles, fungus, etc.). The USDA has experimentally released six insects: five beetles and one midge. Together, these insects feed on the leaves, shoot tips, stems, root crowns, and secondary roots of leafy spurge. Tests in Montana showed up to 90% reduction in spurge population. Experimental releases in a few sites in Wisconsin since 1995 have shown good insect reproduction, and some impact on spurge is becoming evident.

The Forest Service is beginning to pasture goats, which show a strong preference for spurge, in infested areas. The goats are less costly than chemical control measures. It has also been observed that the allelopathic effects of black walnut inhibit this plant's growth.

Chemical Control: Herbicides appear to be a temporary solution in controlling leaf spurge. Land managers who find small infestations of this plant are advised to take immediate action to control it through the application of chemicals.

Picloram is the most effective herbicide for spurge but should not be used in high quality natural areas, as it may seriously affect woody species. This herbicide moves through the soil and is absorbed by roots of adjacent plants up to 30 feet away. Extreme care must be taken in its application. For scattered patches, picloram should be applied according to label recommendations once in late spring and again in early fall; for large infestations, annual applications of picloram in late spring have achieved up to 70% control.

A mixture of quinclorac and picloram was found to provide 85% control of leafy spurge 9 months after treatment. Quinclorac, applied to foliage or to the soil, has been shown to control the plant in the greenhouse environment. If shoot tops are cut at the time of treatment, a lesser concentration of herbicide may be needed than that used to kill intact plants.

A 90% reduction of leafy spurge has been achieved at the University of Wisconsin Arboretum using a solution of fosamine applied to blooming plants in June and July. Fosamine is a bud inhibitor which targets woody species and does not appear to affect herbaceous plants. Control was achieved after one year of chemical application, but follow-up was necessary for three to four years to inhibit germinants from the soil seedbank.

Glyphosate may be used to treat small patches, but requires repeated application. Dicamba has also been cited for selective broadleaf weed control.

Spotted Knapweed (*Centaurea maculosa*)

Description: Spotted knapweed is a biennial or short-lived perennial forb of the composite family. It commonly grows 3-4 feet in height, though individual stem height may vary form two feet on upland sites to four feet on wetter sites. The slender, hairy stems of the plant grow in an erect and branched arrangement, with most stem growth occurring in June. Pale leaves 1-3 inches in length are borne alternately on the stems. The surface of each of the lower leaves is rough, and the leaf margins are indented or divided about halfway to the midrib, giving the leaves a dissected appearance; the upper leaves are more linear in shape. Single, thistle-like, pinkish-purple flowerheads occur at the tips of terminal or axillary stems from late June through August; these flowerheads may reach 3/4 inches in diameter. Each flower head has stiff bracts marked with fine, vertical streaks and tipped with dark, comb-like fringes that give the flowerhead a spotted appearance. Seeds are brownish in color, under 1/4 inch in length, notched on one side of the base, and tipped by a tuft of bristles, enabling wind dispersal. Knapweed has a stout, elongated taproot.

Similar Species: Several plant species that occur in our area resemble knapweed. These include:

- Russian knapweed (*Centaurea repens*): found in disturbed areas, but rarer in Wisconsin.
- Bachelor's button (*C. cyanus*): currently in cultivation and common in "wildflower" mixes; has blue flowers and is generally larger than *C. maculosa* .
- White-flowered knapweed (*C. diffusa*): found in disturbed areas; generally with white flowers, but easily confused with *C. maculosa*.

Distribution and Habitat: This plant was probably introduced in the 1890's as a contaminant in alfalfa or hay seed from Europe and Asia. Spotted knapweed has become a serious problem in the rangelands of the northwestern United States. In recent years, the species has invaded relatively undisturbed natural areas in Wisconsin as well as heavily disturbed sites. The extent of the invasion and the communities affected are not well known. Until recently, spotted knapweed was presumed to inhabit only heavily disturbed areas such as road ditches, agricultural field margins, railroad beds, pipelines, and recently installed utility lines; the plant has now been found in dry prairie sites, oak and pine barrens, and on lake dunes and sandy ridges. It seems to be especially problematic in the central sands, northern Wisconsin, and near the Great Lakes.

Life History and Effects of Invasion: Spotted knapweed reproduces solely by seed. Individual flowerheads bloom from late June through August for 2-6 days each. The bracts reopen after about 20 days and scatter seeds. Seed production averages about 1,000 seeds per plant. Seeds are viable for seven years, and germinate throughout the growing season. Seedlings emerging in fall develop into a rosette of leaves that resume growth in spring.

Spotted knapweed often attains high densities on sunny wild lands, even ones undisturbed by human or livestock activity. Knapweed tends to dominate sites at the expense of community diversity or forage production. Knapweed infestation can also increase surface run-off and sedimentation.

Controlling Spotted Knapweed

Prevention is extremely important, as spotted knapweed spreads readily in hay and on vehicle undercarriages. Caution is necessary when using hay from the road ditches of primary roadways or hay purchased from known infested areas. Outlying plants should be controlled before main populations.

Mechanical Control: The most effective control is early detection and removal of pioneering plants. Small populations can be removed by digging or pulling. This is best done where the soil is moist. The entire root should be removed. Mowing has not been successful, as plants merely reflower at a lower height.

Once established, knapweed may be reduced by hot prescribed burns. These can be followed by selective pulling and digging once the population has been decreased. Annual burns have reduced populations anywhere from five to ninety percent. Reductions seem to correlate to the intensity of the burn administered; burns that remove nearly all the duff are most effective. Following a burn, reseed with native species. The potential effects of intense burning on native species must be taken into consideration when planning a burn.

Biological Control: Several biological controls exist, including two root mining moths, a flower moth, and a root mining beetle. These have met with varying degrees of success. Most promising are the two seed-head attacking flies *Urophora affinis* and *U. quadrifasciata*. Congruently, these two flies have reduced seed production 95% in experimental populations. While both flies are being released experimentally in Wisconsin, their effectiveness here is still unknown, and there are concerns they may impact rare composites. These insects were not available for general use at the time of printing. The USDA should be consulted to determine the current status of these controls.

Chemical Control: Chemical controls are an effective means of eliminating spotted knapweed, but they may also have the most adverse consequences. The recommendations from western rangelands involve the use of some very potent chemicals. These restricted chemicals are not recommended for use on quality natural areas, but may be appropriate on roadsides and other highly disturbed areas. Experimentation testing the effectiveness of less toxic broad-leaf herbicides such as triclopyr or glyphosate is encouraged.

A solution of triclopyr in the water-soluble formulation with dye can be used to kill plants. Triclopyr should be sprayed on the entire plant except the flower, which should be spared for native fauna. This application should be repeated 3-4 times per year for two years. Triclopyr will not affect grasses.

Picloram will control spotted knapweed plants and seedlings for 2-3 years, although the residual control period may be shorter on gravel soil--where soil organic matter is high--or in wet areas. Picloram should be applied either in fall when the plant is in the rosette growth stage, or in spring during the bud to bloom stage. Picloram should not be used near water or on sandy soils with ground water ten feet or less below the surface.

Dicamba also controls spotted knapweed, but may require annual follow-up treatment for a minimum of two years. Clopyralid is more selective, affecting only legumes and composites. A mixture of clopyralid plus 2,4-D is also an option; both herbicides provide good control of spotted knapweed with less soil residual than picloram or dicamba. *However, the herbicide clopyralid does have deleterious effects on lupine at all life stages; its application must be closely monitored.* Spotted knapweed that is still in the rosette stage can be controlled by applying a 2,4-D low volatile ester, oil soluble amine, or water soluble amine formulation. Annual spraying for several years may be required to deplete the seed bank.

Transline® is an herbicide selective for legumes and composites. It is best applied in pre- or early bud stage, but is effective even when plants are in seed. Follow label recommendations for proper application methods and concentrations.

Picloram and clopyralid are the most commonly used and effective herbicides for spotted knapweed. Again, clopyralid does have negative effects on lupine and its use must be closely regulated. Picloram causes the largest initial decrease in native forb cover, but the experiment that produced this data also concluded that most non-target forb populations were tolerant of herbicidal treatments and benefited from being released from knapweed competition after three years of selective herbicidal application. Application of these herbicides has not been found to decrease the frequency of occurrence of grasses, sedges, shrubs, or trees in the treated site. Herbicides were applied manually using a carbon dioxide pressure-regulated backpack sprayer.

Ferns:

Bracken Fern *(Pteridium Aquilinum)*

Description: Growing to several feet in height, the bracken fern has distinctive compound leaves, which are bipinnate-pinnatifid to tripinnate, deciduous, and deltoid to ovate shaped. Leaves have spore-producing sori around the underside margins, and the fronds occur alternately off a long stipe, which is unique in that it has true vessels. The subterranean rhizome is hairy, branched, and creeps significantly.

Distribution and Habitat: Bracken fern is a native plant that occurs most commonly on sandy soils and savannas, preferring partial to full sun. It also occurs on roadsides with sandy soils throughout Wisconsin. It is an opportunistic species, often invading areas after a disturbance such as fire.

Life History and Effects of Invasion: Bracken fern reproduces primarily by vegetative means from the large rhizome, but may also reproduce by spores. The fern can become a serious weed, with its large rhizome resprouting after the leaves are destroyed by cutting or fire. Its opportunistic qualities are such that when there is a disturbance in favorable habitat where it is present, it will further spread to those disturbed areas. The plant also produces a dormant frond at the base of each of the leaves. In the event that a leaf is cut, a new frond will grow to replace it in the same season. Additionally, bracken fern has allelopathic compounds released from summer fronds and decaying vegetation in fall and winter that chemically deters other plants from growing near the fern.

Controlling Bracken Fern

The difficulty in controlling bracken fern is its persistent rhizome. This is also the key to controlling bracken, however, in reducing the plant's food stores in this enlarged root.

Manual Control: Cutting can be an effective control against bracken. Although cutting actually may increase shoots in the short term, due to the capacity of the plant to send up secondary

fronds in the same season, it will reduce the overall height and size of the standing crop. The most effective time to cut is when the rhizome has been depleted somewhat in frond development, but before the fronds start to replenish it again via photosynthesis. This time occurs right after the two or three fronds are fully formed, about mid-June to early July. After several seasons of this, the rhizome will have spent its energy stores growing fronds, but not had any of this energy replenished.

Another mechanical method that can be used in addition to cutting for effective control is the dynamic use of winter frost. By clearing leaf litter around a stand of bracken, the area can become more susceptible to deeper frosts, possibly damaging bracken rhizomes.

Chemical Control: Herbicide treatment can also be a very effective control method, especially when combined with mechanical controls. For the most positive herbicide effects, the chemical should be applied to healthy, fully formed fronds when the plant is replenishing its rhizome. This ensures that the herbicide will be translocated to the rhizome effectively. However, timing is important, as later in the season a thick, waxy cuticle forms on the leaf which can impede herbicide treatments, making them less effective.

Asulum (4-Aminophenyl sulphonyl carbamate) has been shown to be the most effective herbicide on bracken fern, with glyphosphate running a close second. Spot treatments, using a fine spray close to the frond, limit waste and minimize damage done to the underlying soil and vegetation. Herbicide may also be mixed with a dye to mark treated areas.

Herbicide treatments may have to be made annually for up to five years to fully eradicate bracken fern. Prescribed burning, however, in the fall or following spring after herbicide treatment may hasten the effective control. Once bracken is diminished, the area should be seeded with noninvasive native species.

Species of Secondary Concern in Karner Blue Butterfly Habitat

Species of Secondary Concern are no less aggressive or invasive than Species of Primary Concern. These species tend to not be as significant of a problem in Karner blue habitat due to less direct competition with lupine and vital nectar plants, but their management and control is still important.

Trees:

Common Buckthorn (*Rhamnus cathartica*)
Other names: European Buckthorn, Hart's Thorn, European Waythorn, Rhineberry
and
Glossy Buckthorn (*Rhamnus frangula*)
Other names: Alder Buckthorn, Columnar Buckthorn, European Alder, Fen Buckthorn

Description: Both common and glossy buckthorns are tall shrubs or small trees reaching 20-25 feet in height and up to 10 inches in diameter. Most often they grow as large shrubs, with a few to several stems at their bases. Crowns are spreading and loosely-branched. Their bark is gray to brown with prominent, often elongate, light-colored or silvery lenticels. The buckthorns share a very distinctive winter appearance, both having naked, hairy terminal buds and gracefully curving or arching twigs; closely-spaced, prominent leaf scars give the twigs a warty or bumpy silhouette. Cutting a branch of either species exposes a yellow sapwood and a pinkish to orange heartwood. Both species of buckthorn are distinctive enough from other native species to be identified at all times of the year once their characteristics have been learned. The dioecious common buckthorn may be even easier to spot when the female plants are in fruit, for they bear clusters of black, rounded berries.

Common buckthorn has dull green, ovate-elliptic leaves which are smooth on both surfaces and have minute teeth on the margins. They vary from rounded to pointed at the tip. Twigs of this species often end in thorns. Glossy buckthorn has thin, glossy, ovate or elliptic leaves with entire (not toothed) margins; while the upper surface of each leaf is shiny, the lower surface can be either hairy or smooth.

There are several ornamental cultivars of *Rhamnus frangula* including "columnaris" and "asplenifolia." The columnar variety of glossy buckthorn has a very narrow upright growth form and is commonly used for wind or visual screening. It is suspected that the seeds from these cultivars can disperse, producing weedy offspring.

Similar Species: Alder buckthorn (*Rhamnus alnifolia*) is a small native shrub of less than 3 feet in height with twigs that are hairless; dark scales are apparent on the buds in winter. Lance-leafed buckthorn (*Rhamnus lanceolata*), found in bogs and swamps, is a small native shrub of less than

6 feet in height. It has alternate leaves 2-6 inches in length, each of which gradually tapers to a point at the tip; bud scales are apparent on the branches in winter.

Distribution and Habitat: Common buckthorn and glossy buckthorn are two closely related species that originated in Eurasia and were introduced to North America as ornamentals. They were planted in hedgerows in Wisconsin as early as 1849. They have become naturalized from Nova Scotia to Saskatchewan, south to Missouri, and east to New England. They are well established and rapidly spreading in Wisconsin. Although their aggressive growth patterns have created problems in many areas, exotic buckthorns are still legally sold and planted as ornamentals.

Common buckthorn is a problem species mainly in the understory of southern oak, oak-beech, maple, and riparian woods, prairies, and savannas. It also occurs in thickets, hedgerows, pastures, abandoned fields, roadsides, and on rocky sites. It aggressively competes with local flora, mainly on well-drained soils.

Glossy buckthorn is an aggressive invader of wet soils. It has become a problem in wetlands as varied as acidic bogs, calcareous fens, and sedge meadows. This species is not confined to wetlands, however, and grows well in a wide variety of upland habitats, including old fields and roadsides. It is capable of growing both in full sun and in heavy shade. Neither species of buckthorn is adversely affected by nutrient-poor soils.

Life History and Effects of Invasion: Both buckthorns are characterized by their prolific reproduction by seed, long distance dispersal ability, wide habitat tolerance, and high levels of phenotypic plasticity (adjusting physical appearance to maximize environmental conditions). Under full sun conditions, they may begin to produce seed just a few years after establishment, while fruit production may be delayed for 10 to 20 years in shaded habitats. Common buckthorn flowers from May through June and fruit ripens August through September; glossy buckthorn blooms from late May until the first frost and produces fruit from early July through September. The abundant fruits of both species are eaten by birds in late winter, thus encouraging the widespread dispersal of horticultural plantings. Seedlings establish best in high light conditions but can germinate and grow in the shade. The exotic buckthorns have very rapid growth rates and resprout vigorously after they have been cut. Typical of several non-native understory shrub species, buckthorns leaf out very early and retain their leaves late in the growing season.

The first few individuals established in a natural area are usually from seeds transported by birds. Once these individuals begin to produce seed, the buckthorns can rapidly form dense thickets. The vigor of buckthorns is positively correlated to light availability. Once established, both buckthorn species have the potential to spread very aggressively and in large numbers due to their ability to adapt to adverse habitat conditions. Because they maintain their leaves so long, both species cast a dense shade throughout the growing season as they mature into tall shrubs. This shading has a particularly destructive effect on herbaceous and low shrub communities, and

may prevent the establishment of native tree seedlings or shade out native wildflowers. In addition, the diarrhetic quality of the fruits causes an energetic loss in birds who feed on them.

Controlling Exotic Buckthorns

As with all invasive species, buckthorns in natural areas are most effectively controlled by recognizing their appearance early and removing isolated plants before they begin to produce seed. With large infestations, the largest seed-producing plants should be removed first.

Mechanical Control: Prescribed burns in early spring or fall may kill seedlings (especially in the first year of growth), larger stems, and top-killed mature buckthorns, although this method has met with mixed results. Burning is preferable for fire-adapted communities and should not be used if it adversely affects a community. Annual or biannual burning may have to be continued for several years to control buckthorns, depending on the extent of establishment and the size of the seedbank, which generally lasts two to three years. It is often difficult to burn in dense buckthorn stands as the understory is typically well-shaded, allowing little fuel build-up.

In high quality natural areas where the use of chemicals is a concern, small patches of plants up to 0.4 inches in diameter can be pulled when the soil is moist. Larger plants 0.5 inches to 1.5 inches in diameter can be dug or pulled using a weed wrench. Disturbed soil will result from these techniques, and it should be tamped down to further seedling development.

In wetlands with artificially lowered water tables, restoring the water to its historical levels will often kill glossy buckthorns.

It should be noted that cutting stems at any time will likely result in resprouting unless followed by an application of glyphosate herbicide.

Chemical Control: Chemical control methods are best employed during the fall when most native plants are dormant and buckthorns are still actively growing, thus decreasing the risk of affecting nontarget plants. The buckthorns' green leaves will also provide easy recognition and allow for a thorough treatment at this time. Control methods can be implemented during the growing season, but with more risk of affecting non-target plants, and the effectiveness of the treatment is generally lower except in late summer and fall. Winter application of chemicals has proven to be successful as well, and further decreases the risk of damaging non-target species.

Cutting stems off near ground level and treating them with glyphosate successfully curbs sprouting. Immediately after cutting, glyphosate should be applied to the stumps; for larger stumps, herbicide application should be directed to the vascular tissue just inside the bark (the phloem). Resprouts should be cut and the stumps treated again, or, if left uncut, treated with a foliar spray of glyphosate solution applied with a hand sprayer. Foliar application of glyphosate herbicide using a backpack sprayer can also be effective, but is best used on areas with large numbers of buckthorn seedlings which need to be treated. Spraying should be done in the autumn, well before the buckthorn leaves have begun to drop and at a time when temperatures are likely to remain above freezing for a few days. Glyphosate concentrations are generally low for foliar sprays and higher for stump application. Check herbicide labels for accurate dilution rates. Dyes can be added to help identify areas treated.

For severely disturbed sites, a triclopyr solution diluted in water can be applied to freshly cut stumps with a low pressure hand sprayer, a spray bottle, or sponge applicator; a tricolopyr solution formulated for oil dilution can also be effective as a cut stump treatment. Basal bark application of triclopyr solution (formulated for oil dilution) or 2-4-D in diesel fuel may be used to control buckthorns as well. For stems larger than 2 inches, the mixture is most effective when sprayed all the way around the stem; for smaller stems, spraying one side is sufficient. This treatment may not be effective on larger trees.

Fosamine (water dilution), a non-selective bud inhibitor for woody species, can be applied as a foliar treatment in the fall. This will not kill all plants, but mortality will be apparent the next growing season.

Shrubs:

Autumn Olive *(Elaegnus umbellata)*

Description: Autumn olive is a deciduous shrub with a widely spreading crown, usually growing to a height of 10 to 15 feet, but not uncommonly reaching 20 feet. The actual shape of the plant may vary from narrow and upright to dwarf-sized with laterally spreading branches. The tooth-less leaves are single and alternate, 1 to 4 inches, and elliptic to ovate in shape. Lower leaf surfaces are green with silvery scales, a distinguishing characteristic for this species. The half-inch trumpet-shaped flowers are white to light yellow, appear in May, and grow singly or in clusters along the twigs and small branches. The abundant quarter-inch fruits are berry-like, pinkish to red, and are finely dotted with pale scales.

Distribution and Habitat: Autumn olive is a native of China, Japan, and Korea, and was introduced in the US in 1830. In Japan the species grows commonly in thickets and along streams and roadsides. Beginning in the 1940s in the US it was promoted by federal and state agencies as food and cover for wildlife, windbreaks, highway barriers, roadside stabilization, and

reclamation projects on mining lands. The variety 'Cardinal' was developed in 1963 for these purposes. The species is now found across the eastern half of the US.

Autumn olive is an adaptable species, tolerant of a wide range of soils and climates. It usually occurs on disturbed sites, fields, roadsides, prairies, and other areas that are not too wet. In Wisconsin, it grows best on sandy loam soils typical of drier areas. It prefers full sun, but exhibits intermediate shade tolerance, sacrificing fruit production.

Life History and Effects of Invasion: Autumn olive is a non-leguminous, nitrogen-fixing woody shrub. Plants flower and develop fruits annually after reaching 3 years of age, although 2-year-old plants have been known to flower. An individual plant can produce up to 8 pounds of fruit. Seed dispersal is mainly through falling fruit and birds, which may be the primary distribution method. Burned, mowed, or cut plants will resprout vigorously.

Controlling Autumn Olive

Once established, autumn olive is difficult to control. As with all invasive species, autumn olive plants in natural areas are most effectively controlled by recognizing their appearance early and removing isolated plants before they begin to produce seed. With large infestations, the largest fruit-producing plants should be removed first.

Mechanical Control: Young seedlings and sprouts can be hand pulled in early spring when adequate ground moisture is present to allow removal of the root system along with above-ground growth. Autumn olive is easily seen in early spring because its leaves appear while most native vegetation is still dormant. Larger plants 0.5 inches to 1.5 inches in diameter can be dug or pulled using a weed wrench. Disturbed soil will result from these techniques, and it should be tamped down to further seedling development.

Prescribed burning is preferable for fire-adapted communities and should not be used if it adversely affects a community. Annual or biannual burning may have to be continued for several years to control the autumn olive, depending on the extent of establishment and the size of the seedbank, which may last two to three years.

Chemical Control: A combination of mechanical and chemical treatment appears to be the most successful in controlling autumn olive. Cutting the plant off at the main stem and applying herbicide to the stump has been effective in killing root systems and preventing resprouting. Herbicides recommended include glyphosate, triclopyr, and fosamine. With cut-stump treatment, herbicide is applied specifically to the target plant, reducing the possibilities of damaging nearby, desirable vegetation. Cut-stump treatment is particularly effective late in the growing season (July-September), but is also effective during the dormant season. Treatment of cut stumps should be done as soon as possible after cutting, i.e. within a few minutes, and care should be taken to avoid contact with nontarget species. Treatment should also not be planned less than 8

hours before predicted rain. Resprouts should be cut and the stumps treated again, or, if left uncut, treated with a foliar spray of glyphosate solution applied with a hand sprayer. Foliar application of glyphosate herbicide using a backpack sprayer can also be effective, but is best used on areas with large numbers of buckthorn seedlings which need to be treated. Spraying should be done in the autumn, well before the leaves have begun to drop and at a time when temperatures are likely to remain above freezing for a few days. Glyphosate concentrations are generally low for foliar sprays and higher for stump application. Check herbicide labels for accurate dilution rates. Dyes can be added to help identify areas treated.

For severely disturbed sites, a triclopyr solution diluted in water can be applied to freshly cut stumps with a low pressure hand sprayer, a spray bottle, or sponge applicator; a tricolopyr solution formulated for oil dilution can also be effective as a cut stump treatment. Basal bark application of triclopyr solution (formulated for oil dilution) or 2-4-D in diesel fuel may be used to control autumn olive plants as well. For stems larger than 2 inches, the mixture is most effective when sprayed all the way around the stem; for smaller stems, spraying one side is sufficient. This treatment may not be effective on larger trees.

Fosamine (water dilution), a non-selective bud inhibitor for woody species, can be applied as a foliar treatment in the fall. This will not kill all plants, but mortality will be apparent the next growing season.

Forbs:

Exotic Hawkweeds (*Hieracium* spp.)

Species: *Hieracium aurantiacum*, orange hawkweed; *H. caespitosum* (formerly *H. pratense*), field hawkweed or yellow king-devil; and *H. piloselloides* (*H. florentinum*), tall hawkweed. There is also a hybrid of *H. aurantiacum* and *H. piloselloides* that has less invasive habits.

Description: Most of the invasive hawkweeds of Karner Blue butterfly habitat have their leaves in a basal rosette at the base of a flowering stem. In *H. caespitosum* the leaves and stem are conspicuously hairy and free of leaves, and the basal leaves are significantly longer than they are wide. *H. piloselloides* resembles *H. caespitosum*, but its leaves are less hairy and, along with distinctive single flower heads, are slightly smaller. Flowers of *H. caespitosum* and *H. piloselloides* are both shades of yellow, while *H. aurantiacum* has distinctive orange flowers. Flowers resemble small dandelion heads, but are in clusters of at least two, and usually more, heads at the top of the stem.

Hawkweeds may grow from rhizomes (horizontal underground stems), or stolons (horizontal above-ground stems), resulting in small patches of the plant, or may grow singly. They are very prone to hybridization, resulting in difficult identification at the species level.

Distribution and Habitat: Hawkweeds are found throughout Wisconsin in drier habitats. Several species were introduced from Europe in the latter part of the 1800s to the early 1900s. Hawkweeds are usually found on poor, dry, sandy or gravely soils. They are common on savanna habitats, roadsides, old fields, disturbed areas, and railroad right-of-ways.

Life History and Effects of Invasion: Flowers are produced in June and early July, and intermittently after that. Seeds are dispersed by the wind, and can germinate very soon after dispersal. Foliage may persist through the winter months. It is likely that most hawkweeds are allelopathic, that is, they are capable of chemically altering the soil to inhibit the growth of competing plants.

Controlling Exotic Hawkweeds

Locating and removing plants immediately before seed sets is the best way to prevent the spread of hawkweeds. When removing by hand, however, it is important to wear protective gloves. Be sure to check the contents of "wildflower" seed mixes for these species, and do not plant those that carry them. Also, after controlling hawkweeds, it is important to get a good stand of native grasses established to effectively keep hawkweeds down.

Mechanical Methods: Any plant whose seed may escape to roadsides or woodlots should be eradicated or prevented from going to seed by cutting the flower heads after they bloom. Pulling may need to be done for several years to remove new plants established from the seed bank. Pulling or use of a dandelion digger is most effective when the soil is moist. If plants are pulled when in bloom, they should not be placed in compost piles, as the seeds may ripen and spread. Flower-heads should be bagged for landfill, or dried and burned where permissible. Where there is sufficient leaf litter or other fuel, burning has been found to be an effective control method.

Chemical Methods: Selectively applying a broadleaf herbicide to seedlings according to label recommendations may be an effective means of control. To avoid damaging native vegetation, apply herbicide in late fall when the rosettes are still green.

Yellow Sweet Clover (*Melilotus officinalis*)
and
White Sweet Clover (*Melilotus alba*)

Description: The sweet clovers, members of the legume family, are very similar in appearance except for the distinguishing colors of their flowers, which are either yellow (*M. officinalis*) or white (*M. alba*). Yellow sweet clover is usually smaller than white sweet clover and blooms earlier. Both species are biennial, producing shoots which are strictly vegetative in the first year and flower-bearing in the second. During the first year of growth, the sweet clovers have small, branched stems bearing compound, clover-like leaves; the leaves are divided into three finely toothed leaflets, the middle leaflet occurring on a distinct stalk above the other two. In the second year, plants may appear bushy, growing from three to five feet in height. When in bloom, they produce flowers which are packed densely on the top four inches of an elongated stem; each small flower in a cluster is attached to the stem by a minute stalk.

Distribution and Habitat: Sweet clovers are native to Europe and Asia. They were brought to North America in the late 1600's as an agricultural crop for forage and honey production. These clovers fix nitrogen, and thus became popular as soil enhancers. The chemical used in the production of the blood thinner Warfarin was first discovered in sweet clover. Due to the economic values of white and yellow sweet clover, these species will continue to be planted despite the problems they pose for land managers.

Both species are found in all fifty states, although they are most frequently found in the states of the Upper Midwest and Great Plains. Sweet clovers grow well in direct sunlight or in partial shade, but neither species can tolerate complete shade. Sweet clovers seem to prefer calcareous or loamy soils, and are most frequently found in open, disturbed, upland habitats, such as prairies, savannas, and dunes.

Life History and Effects of Invasion: Sweet clovers are fire-influenced, aggressive, weedy plants whose populations tend to show high rates of fluctuation. Both species degrade native grasslands by overtopping and shading native sun-loving species; it has also been suggested that these clovers produce allelopathic chemicals.

Both white and yellow sweet clovers are biennials. After germination in late spring or summer, the plants put their energy into developing a healthy root system. First-year plants can be seen by late summer. In the second year, plants may appear in late April or early May. By that time, individuals have a strong taproot and a root crown from which new shoots appear. Plant height is dependent on root development and growing conditions; healthier plants are taller. Sweet clovers flower from late May through September, set seed, and die. Both plants produce small, hardy seeds that remain viable in the soil for as long as thirty years.

Burning produces excellent growing conditions for clover by scarifying seeds and stimulating

germination. During the year following a burn, many flowering plants generally emerge.

Controlling Sweet Clover

Sweet clover can be managed using mechanical controls, and should not require chemical use.

Mechanical Control: On grasslands managed with prescribed burning, it is possible to greatly reduce sweet clover by burning two years in a row. Burning should be done early the first year (before green-up, which is usually in early to mid-April) to stimulate germination of natives. However, it should be noted that early burning may disrupt the phenology of lupine, a plant critical in the Karner blue butterfly life cycle. The burned area should be checked in late summer for first year clover plants. If plants are found, another burn should be conducted the next year in early to mid May; if burning is conducted before the buds are developed, the plants will resprout. Heavily infested areas may need this burning sequence repeated after a few years. The fire may be of low intensity—just enough to touch the stems. Damaged plants wither quickly if they are not completely destroyed by fire. For small patches or those areas not completely burned, a flame gun (torch) may be used when the vegetation is damp to avoid burning surrounding prairie. Another burning strategy is to mow later in the summer, allow the cut plants to dry, and then burn. This can be stressful to the native vegetation and should not be done annually.

Small amounts of sweet clover can be controlled by hand-pulling. Pulling should be done in late fall after the root crown buds of first-year plants have developed or in May or June before second-year plants flower. Pulling is easier when the soil is wet. If pulling is tried too early, many plants may be missed, and those with succulent stems may break off and resprout; however, pulling must be done before seeds are set, otherwise pulled plants will have to be removed from the natural area. It is necessary to inspect the area a couple of times in summer for late-flowering plants.

If pulling plants is not an option, plants can also be cut. Plants can be cut at ground level with brush loppers, or, in very dense, small patches of clover, cut with a power brush-cutter using a heavy duty saw blade. The stand should be cut just before flowering, and checked a week later for individuals missed or only partly cut.

It is necessary to conduct annual inspections to remove scattered individual plants. Disturbed areas such as fox dens provide habitats that can allow sweet clover to greatly increase its numbers over time if not controlled. Habitats adjacent to managed areas should also be inspected to reduce sweet clover invasion on managed sites. Due to the long viability of sweet clover seeds (up to 30 years) and continued agricultural use, these plants must be managed on nearly a continuous basis.

Wild Parsnip (*Pastinaca sativa*)

Description: Wild parsnip is a member of the carrot family (Umbelliferae or Apiaceae). It is a monocarpic perennial, meaning it produces flowers only once during its life; it persists as a basal rosette until flowering conditions are right, blooms, then dies. During its vegetative stage, parsnip produces a rosette which lies close to the ground and is composed of leaves averaging six inches in height; this rosette is anchored in place by a long, thick taproot. When conditions are favorable, the plant gives rise to a single, thick stem that bears hundreds of yellow flowers, arranged in umbels. The lateral flowers in an umbel often overtop the central terminal flowers. Depending on the habitat and growing conditions, individual flowering plants can range to over four feet in height. Leaves are alternate, pinnately compound, and branched; each leaf has 5-15 ovate to oblong leaflets with saw-toothed margins and deep lobes.

Similar Species: Wild parsnip can be confused with prairie parsley (*Polytaenia nuttallii*), a native prairie species listed as threatened in Wisconsin, as the flowers and leaves of the two species are similar, though not identical. The flowers of the prairie parsley plant are light-yellow, sparse, and typically found at the end of the stem; leaves are pinnately compound like those of the wild parsnip, but leaflets are oblong and have few teeth.

Distribution and Habitat: Wild parsnip is tolerant of a wide range of habitat conditions, including dry, mesic, and wet-mesic prairies; oak openings; and calcareous fens. This plant is shade-intolerant and prefers sunny conditions.

Life History and Effects of Invasion: Wild parsnip can cause phytophotodermatitis to the skin. If the plant juices come in contact with skin in the presence of sunlight, a rash and/or blistering can occur, as well as skin discoloration that may last several months.

This species reproduces readily from seed; seeds are fairly large and many may be produced by a single plant. As a monocarpic perennial, wild parsnip spends one or more years as a basal rosette; when conditions are favorable, it flowers, produces seed, and dies. The large, coarse, flower spikes and yellow flowers of wild parsnip generally appear from the first of June to the middle of July (although some plants may continue flowering through late summer); optimal growing conditions may stimulate an increase in flower production. Apparently, seeds become viable three weeks or more after flowering occurs.

Wild parsnip slowly invades an area in waves following initial infestation. Once its population builds, the plant spreads rapidly. An aggressive, Eurasian weed, wild parsnip frequently invades and modifies a variety of open habitats.

Controlling Wild Parsnip

Caution: When dealing with this plant, care must be taken to prevent plant juices from coming into contact with bare skin; proper clothing (gloves and a long-sleeved shirt) must be worn to prevent the discoloration and discomfort caused by phytophotodermatitis.

Mechanical Control: The best way to control wild parsnip is through early detection and eradication. Small populations of parsnip can be effectively controlled by cutting the entire root of each plant just below ground level with a sharp shovel or spade (cutting below ground level prevents resprouting). In some soil types under wet conditions, plants can be pulled out of the ground by hand. When controlling parsnip by cutting or pulling, all seeds must be removed from the site and disposed of in a landfill or by burning to help prevent new plants from sprouting.

If the population is too large to hand-cut or pull, a power brush-cutter can be used just after peak flowering and before the seeds set. Plants may resprout when cut above the ground, and should be cut again a few weeks later to prevent flowering. Cutting may also be done after seed set, greatly reducing the likelihood that plants will be able to resprout and flower; plants cut at this time must be gathered and removed from the site to prevent mature seed from developing and falling to the ground. The potential for reseeding can also be eliminated by hand-collecting all seeds after they have set. If control methods for flowering or seeding plants are carried out over several years, the population of wild parsnip will decrease as the seed bank is depleted.

Burning does not seem to impact wild parsnip, as plants quickly resprout following a fire. However, parsnip rosettes are easy to recognize on the darkened soil left by burning and can be eradicated by hand-digging. Prescribed burning stimulates increased growth in prairie species whose spread may potentially decrease parsnip populations through competition.

Chemical Control: Chemical controls are effective, but should be used sparingly on quality natural areas. The best method is to burn the site then follow with spot application of glyphosate, as wild parsnip is one of the first plants to green after a burn. Glyphosate can be spot applied to the basal rosette of parsnip with little effect on dormant species.

Grasses:

Kentucky Bluegrass (*Poa pratensis*)
and
Canada Bluegrass (*Poa compressa*)

Description: Most of the cool-season grasses that emerge early in the growing season are not native to Wisconsin prairies. Exotic bluegrasses can be distinguished vegetatively from other early grasses by the appearance of their leaves, the narrow blades of which are V-shaped in cross-section and the tips of which are shaped like the bow of a boat. Kentucky bluegrass is distinguished from Canada bluegrass by the shape of the stem in cross-section; in Kentucky bluegrass the stem is round, while in Canada bluegrass it is flat.

Many of the other cool-season European grasses (brome, timothy, orchard grass, quack grass, etc.) have similar growth habits and can be controlled using the techniques discussed below.

Distribution and Habitat: Kentucky bluegrass is from Europe, although it is thought to be indigenous to the mountains of the Northeastern United States along the Canadian border. The many cultivars of this grass bred for turf use are derived from the European plants. Due to the extensive use of Kentucky bluegrass for lawns and in pastures, it is now commonly found in grasslands, even those managed for native species. Like Kentucky bluegrass, Canada bluegrass is naturalized from Europe. The effects of these grasses on natural systems are similar and therefore should be treated as one problem.

Kentucky bluegrass is a common lawn and pasture grass. It is found in meadows, fields, and semi-open woods throughout the United States. Canada bluegrass is often mistaken for Kentucky bluegrass, but tends to form extensive sods in dry, sterile soils (especially acidic soils) that cannot sustain the more common Kentucky bluegrass. Kentucky bluegrass is usually found on mesic and fertile soils, although it will grow on dry neutral or alkaline soils.

Life History and Effects of Invasion: Because bluegrass grows early in the season (when most other species are still dormant), it can spread very quickly without the hindering effects of competition. However, its shallow root system makes it susceptible to high soil temperatures and low soil moisture.

In spring, leaf growth accelerates after temperatures in the upper 1/2 inch of topsoil exceed 50^{o} F. Production of bluegrass increases during April and peaks in May when soil temperatures average 60^{o}-64^{o} F. Production declines when soil temperatures exceed 80^{o} F and does not significantly resume (even with abundant soil moisture) until soil temperatures drop again in late summer.

Bluegrass has successfully invaded both remnant and restored prairies, savannas, and barrens. Establishment can be attributed to intentional introduction, past mowing, grazing, or cessation of

fire. Kentucky bluegrass has the ability to replace prairie grasses that are shaded for half of the day. If left unattended, bluegrass can outcompete native prairie grasses and forbs, and will dominate areas shaded by invasions of woody species.

Controlling Bluegrass

Mechanical Control: A controlled fire can dramatically reduce the bluegrass population in a native or planted prairie, savanna, or barrens. Fire will also set back the woody species whose shade encourages the proliferation of cool-season grasses. Observing bluegrass growth is essential for effective control by burning, as timing of burns may need to be changed on a year-to-year basis depending on weather conditions that help or hinder bluegrass growth; fire is most effective when bluegrass is three to eight inches high. (In southern Wisconsin, a late April or early May burn will generally destroy three to eight inches of new bluegrass growth.) Burning at this time not only kills new growth but removes the moisture-retaining blanket of leaf litter, increasing stress on the shallow-rooted bluegrass by exposing the darkened soil surface to the sun. Burning further reduces the competitive ability of bluegrass by encouraging summer dormancy, thereby decreasing the chance of flowering and seed production. The effect is most pronounced on dry prairies and barrens, where burning can reduce bluegrass by more than 90% (it is rarely 100% effective). Burning at the right time also improves the competitive advantage of native, warm-season grasses and forbs, as later-emerging native species benefit from the elimination of duff and production of a darkened soil surface.

When converting areas dominated by cool-season grasses into prairie, it is helpful to reduce the grass cover and seed bank before planting native seeds. This can be accomplished by any combination of tilling, smothering the grass, or applying herbicide. Till several times a year for at least one season to expose the seed bank and prevent further growth of the grass sod. Herbicide use followed by a season of tilling may also be effective in controlling bluegrass. On small sites, grasses can be killed by covering with black plastic or layers of newspapers during the growing season.

Chemical Control: Herbicide use is not recommended to control bluegrass on grasslands or savannas where there are native prairie plants. However, herbicide may be required on severely degraded areas or where prairie restoration is beginning. In such cases, the herbicide glyphosate has proven effective when used according to label recommendations. Herbicides which selectively target grasses and other monocots may also be used with caution.

Reed Canary Grass (*Phalaris arundinacea*)

Description: Reed canary grass is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades that range from 3 1/2 to 10 inches in length and 1/4 to 3/4 inches in width. Leaf blades are flat and roughly textured on both surfaces; leaf ligules (found on the upper side of the leaf at the junction of the blade and sheath) are membranous and long. During flowering, the plant produces spikelets; each spikelet contains two diminutive flowers, one fertile and one sterile, and is subtended by a pair of bracts (called a glume). Spikelets are clustered into compact panicles, which can be either erect or slightly spreading depending on the plant's reproductive stage; panicles range from 3 to 16 inches in length, with lateral branches 2 to 12 inches in length. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the U.S. The Eurasian variety is considered more aggressive, but no reliable method exists to tell the ecotypes apart. It is believed that the vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

Similar Species: Reed canary grass resembles non-native orchard grass (*Dactylis glomerata*), but can be distinguished by its wider blades, narrower, more pointed inflorescences, and hairless glumes and lemmas (scales which subtend the individual flowers of a grass spikelet). Additionally, bluejoint grass (*Calamagrostis canadensis*) may be mistaken for reed canary grass, especially in the spring. The highly transparent ligule on reed canary grass is helpful in distinguishing it from the others. Ensure positive identification before attempting control.

Distribution and Habitat: Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. The Eurasian ecotype has been selected for its vigor and has been planted throughout the U.S. since the 1800's for forage and erosion control. It has become naturalized in much of the northern half of the U.S., and is still being bred and planted on steep slopes and banks of ponds and created wetlands.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas such as berms and spoil piles.

Life History and Effects of Invasion: Reed canary grass spreads aggressively, reproducing by seed or creeping rhizomes. For 5 to 7 weeks after germination in early spring, the plant produces leaves and flower stalks; it then spreads laterally. Growth peaks in mid-June and declines in mid-August, with a second growth spurt occurring in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and

shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas, but can easily move into native wetlands. Invasion is often associated with disturbances such as wetland ditching, stream channelization, swamp deforestation, sedimentation, drawdowns, and intentional planting. The difficulty in implementing selective control of this species makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites.

Controlling Reed Canary Grass

Reed canary grass is difficult to eradicate; no single control method is universally applicable. In natural communities, mechanical control practices are recommended. In buffer areas and in severely disturbed sites, chemical and mechanical controls may be used. If herbicide is used, care should be taken to prevent contact with non-target species. Any control technique to reduce or eliminate reed canary grass should be followed by planting native species adapted to the site.

As reed canary grass can enter a wetland area from eroding hillslopes, erosion control and catch-basins around preserved wetlands are appropriate preventative measures.

Mechanical Control: Small, discrete patches of reed canary grass may be mowed and covered by black plastic for at least one growing season; the bare spot can then be reseeded with native species. This method is not always effective and must be monitored because rhizomes can spread beyond the edge of the plastic.

In small areas with few natives, cultivation for one full growing season followed by dormant seeding near the first-frost date may help to push out reed canary grass. Disrupting the plant roots every two to three weeks weakens the remaining plants and depletes the seed bank. In certain areas, cultivation combined with spot herbicide application in sections too wet for early or late cultivation has yielded good results in canary grass control. Frequent and continued cultivation is important since one or two cultivations will simply cut the roots up and increase the number of individual plants.

Some sites with heavy infestations caused by ditching may be good candidates for excavation. Using machinery, remove reed canary grass sod to a depth of at least 12 inches. Use the sods to fill the ditches; this will help restore wetland hydrology. Planting with natives may not be necessary if there is viable seed in the soil.

Mowing three times yearly may help control reed canary grass. Mowing should be done in the spring to retard growth, at flowering to prevent seed formation and suppress tillering and in late

fall to repress growth in the following year. Mowing can also expose the ground to light and help to promote the growth of native wetland species. Hand-pulling or digging may work on small stands in the early stages of invasion. Grazing can enhance diversity, although it may stimulate reed canary grass.

Prescribed burns in late spring or late fall may help reduce the reed canary grass population, but must be repeated annually for 5 to 6 years. These fires may be difficult to conduct due to water levels and/or the greenness of the grass at the time of burning. The application of glyphosate will "brown off" reed canary grass enough to conduct prescribed burns. Burning is ineffective in dense stands of reed canary grass that lack competition from native fire-adapted species in the seed bank. A late-spring burn followed by mowing or wick-application of glyphosate to the emerging flowering shoots will kill some plants and eliminate most reed canary grass seed production for that year.

Chemical Control: It is important to realize that, while herbicide kills reed canary grass, the seed bank may germinate and recolonize the site. Several herbicidal applications may be necessary to inhibit seed bank recolonization. After the first application of herbicide has killed living plants, disturbance of the soil can encourage seed bank germination. When this occurs, the site can again be treated with herbicide to deplete the seed bank. Because reed canary grass productivity is reduced by shade, planting native shrubs or wetland trees in areas of chemically-treated grass may further help to suppress its spread.

Small, scattered clones (2 feet in diameter) can be controlled by tying the stems together just before flowering, cutting them, and applying glyphosate solution to cut stems. A formulation of glyphosate designed for use in wetlands will kill reed canary grass (especially young plants) when applied to foliage. Apply in early spring when most native plant species are dormant. Any herbicide application should be done only after removing dead leaves from the previous year in order to maximize growing shoot exposure and minimize the amount of herbicide needed. DNR permits must be obtained for the use of herbicides on or near surface water.

A solution of glyphosate formulated for use over water can be applied as a foliar spray. Two herbicidal applications may be necessary to ensure complete coverage. Herbicide applied with a wick applicator attached to a tractor affects taller stands of reed canary grass without impacting the shorter vegetation.

Late mowing in mid-September followed by application of glyphosate in October (after most native plants are dormant) can help control reed canary grass. Alternatively, wick application of glyphosate in the first to third weeks of June, followed by a late June to mid-July burn, reduces reed canary grass cover, depletes the seed bank, and stimulates native seed banks.

In non-aquatic environments, Dalpon™ and Trichloracetic (TCA)™ effectively treat reed canary grass when applied in late fall or early winter. Both are soil sterilizing herbicides that must be

sprayed on dried foliage. Aquatic systems may also be treated with Dalpon^{TM} for control up to two years. Dalpon^{TM} is weakly cationic (positively charged) and is not absorbed by substrates the way most herbicides are.

Species of Minor Concern to Karner Blue Butterfly Habitat

While less significant to Karner blue habitat than Species of Secondary or Primary Concern, the following Species of Minor Concern can still occur, thus making their control necessary. Again, if conditions are favorable, the following species can be just as aggressive and invasive as species in either of the previous categories, but their direct effects on lupine and vital nectar plants is less significant.

Trees:

Siberian Elm (*Ulmus pumila*)

Description: Siberian elm is a small to medium-sized tree that has an open, round crown of slender, spreading branches. It generally reaches 50-70 feet in height and has bark that is gray to brown, becoming furrowed at maturity. Both the buds and twigs of the tree are nearly hairless. This elm is distinguished from others by its small, elliptical, singly-toothed leaves, each of which reaches a length of approximately 0.8-2.6 inches. The leaves can be either tapering or rounded at their asymmetrical bases; they occur alternately on the tree and are dark green and smooth above, paler and nearly hairless beneath. Foliage is slightly pubescent
when young. Flowers are greenish, lack petals, and occur in small drooping clusters of 2-5 blossoms. Each winged fruit possesses one seed that is circular or ovate in shape, with a smooth surface. Fruits are about 1/2 inch wide and hang in clusters.

Similar Species: As mentioned above, several other elms occur in Wisconsin that may be confused with the Siberian elm. These include American elm (*Ulmus americana*), slippery elm (*Ulmus rubra*), and Chinese elm (*Ulmus parviflora*); the first two are native, the last exotic. Siberian elm can be distinguished from the native elms by observation of its leaves: Siberian elm has relatively small (rarely more then 2 inches), singly-toothed leaves with symmetrical (or nearly so) bases, while both American and slippery elms have larger (typically over 2.8 inches), doubly-serrate leaves which are strongly asymmetrical at their
bases. Chinese elm is exotic but not as invasive Siberian elm. Its leaves have apices and teeth that are less sharply acute than those of Siberian elm. Chinese elm flowers in late summer or fall.

Distribution and Habitat: Siberian elm is a fast-growing tree that was introduced to the United States in the 1860's. Native to northern China, eastern Siberia, Manchuria, and Korea, it is the hardiest of all elms and does well even in areas with cold winters and long periods of summer droughts. Because this elm tolerates a variety of conditions such as poor soils and low moisture, it is found in dry regions including roadsides, pastures, and grasslands. The tree

also grows in moist soils along streams. It can invade dry and mesic prairies, including sand

prairies. It is now established from Minnesota south to Arkansas and west to Utah.

Life History and Effects of Invasion: This tree flowers in spring before the leaves begin to unfold. The fruits develop quickly and are disseminated by wind, allowing the species to form thickets of hundreds of seedlings on bare ground. Seeds germinate readily and seedlings grow rapidly.

Controlling Siberian Elm

Mechanical Control: Girdling trees is the preferred management technique for Siberian elm. Girdled trees die slowly over the course of one to two years and do not resprout. Girdling should be done in late spring to mid-summer when sap is flowing and the bark easily peels away from the sapwood. When girdling, the bark must be removed in a band around the tree trunk just to the outside of the wood. If girdled too deeply, the tree will respond by resprouting from the roots. If resprouting should occur, the resprouts should be cut.

Seedlings can be pulled by hand, and small trees can be removed carefully with a grub hoe or weed wrench. Wind-dispersed elm seeds from nearby areas are often a greater threat than resprouting of established elms. Managers should eliminate nearby Siberian elms whenever possible.

A regular fire regime should control Siberian elm in fire-adapted communities, although saplings older than a few years may not be killed by fire; on these older saplings, another control method, such as girdling, should be tried.

Chemical Control: Glyphosate may be used as a cut-stem application for large trees and resprouts; it should be applied in the fall or winter. If herbicide is used, care should be taken to prevent contact with nontarget species.

Shrubs:

Multiflora Rose (*Rosa multiflora*)

Description: A member of the rose family (Rosaceae), multiflora rose is a dense spreading shrub with wide, arching canes and stiff curved thorns. Older plants may reach up to 15 feet in height and have a root crown more than 8 inches in diameter. The leaves of multiflora rose are pinnately compound and borne alternately on the branches; each leaf usually has seven to nine small (1/2 to 1 inch) oval leaflets with toothed margins. The leaflets are nearly smooth on their upper surfaces and paler with short hairs on their undersides. The shrub produces numerous white flowers which blossom in late spring, forming a panicle from 1/2 to 1 1/2 inches across. While native roses

usually have pink flowers, those of multiflora rose are usually white. At maturity, the flowers develop into small, hard, round red fruits (called hips) that are about 1/4 inch in diameter. The hips remain on the plant throughout the winter. The seeds are angular achenes.

By law, multiflora rose is considered a nuisance weed, and cannot be sold or propagated.

Distribution and Habitat: Introduced from Japan in 1886 as rootstock for cultivated roses, multiflora rose was promoted as a means to curb soil erosion by the U.S. Soil Conservation Service in the 1930's. The nursery industry touted the shrub as a "living fence" to control livestock and create snow barriers along highways. It was promoted by wildlife managers as late as the 1960's as an excellent source of food and cover for wildlife. Due to its dense growing habits, it has become a serious problem in the eastern United States and occurs throughout the U.S.

Multiflora rose has naturalized in most of the northeastern and midwestern United States. Although abundant throughout Illinois, it is currently only becoming a problem in southernmost tier of Wisconsin counties. Presumably, its northern range is limited by an inability to tolerate winter temperatures below -28^{o}F, although this limit may only apply to seedling establishment. The plant is found in old fields, pastures, roadsides, and forests; it can tolerate a wide range of soil and environmental conditions, but thrives in sunny areas with well-drained soils. Multiflora rose is not found in standing water or extremely dry habitats.

Life History and Effects of Invasion: Multiflora rose blooms in May or June, the flowers giving rise to hips which may either fall near the parent plant or be dispersed for longer distances by birds and mammals, which feed on the fleshy fruits. Individual plants may produce up to 500,000 seeds per year, many of which will germinate near the parent plant; seeds may remain viable for 10-20 years. The shrub can also spread vegetatively, as its canes are capable of rooting when in contact with soil. Multiflora rose readily invades pastures, prairies, savannas, open woodlands, and forest edges. Where it grows in dense thickets, it occludes the surrounding vegetation.

Controlling Multiflora Rose

Mechanical Control: Scattered populations of multiflora rose in high-quality natural areas can be effectively controlled by complete removal (uprooting and disposal) of the plants. All roots must be removed because new plants can grow from severed roots. Mowing with heavy equipment has also proven effective in controlling the shrub, especially when repeated 3-6 times a year for at lest 2-4 years. Because the strong thorns have been known to puncture rubber tires, tires may have to be filled with foam to keep them from going flat. Smaller plants can be pulled with a weed wrench. In areas where multiflora rose is just beginning to invade, fire can limit its establishment. Follow-up monitoring is necessary because new plants can arise from root fragments or previously dormant seeds.

Chemical Control: Manual application of herbicides on freshly cut stems has proven an effective means of control, as it can destroy the root system and prevent resprouting. A solution of glyphosate can be used effectively if applied to cut stems or canes during the growing season (between July and September) or during dormancy; in fact, application during dormancy is preferable because it reduces the likelihood of damaging surrounding species. A foliar spray of glyphosate solution applied to flowering or budding plants may also be effective in killing the plant, especially when the flowers are in full bloom or when plants are young. Glyphosate is non-selective and should not be used in high-quality natural areas.

Triclopyr formulated for water dilution can be applied to cut stems or canes; it should be applied using a hand-held sprayer within a few hours of cutting. Again, dormant season is the best time for application to ensure non-target species are not damaged by run-off.

Foliar sprays may also serve to get rid of multiflora rose. Fosamine is the preferred foliar spray treatment because it is non-volatile and will only affect woody species. A foliar spray of fosamine solution in water can be effectively used from July to September if the foliage is well covered. Die-back will not be apparent until the following summer. A solution of dicamba can also be applied as a foliar spray. Dicamba is selective against broadleaf species and should never be used if desirable broadleaf vegetation is present. Application is most effective during May or June when plants have achieved full leaf-out and are flowering.

A pellet formulation of tebuthiuron (spike 80w) is often used to kill multiflora rose. Pellets are thrown at the base of the plant and gradually permeate the soil. This herbicide will kill any other woody plants whose roots come into contact with it, so pellets should not be used on slopes or prior to heavy rainstorms when they may be washed into nearby waterways, essentially killing everything in their path.

A handful of water softener salt place at the base of the plant has apparently proven effective, but will remain in the soil for many years. Also effective is burning the bush itself. Spray the shrub with a gas and oil mixture, then light. This sterilizes the ground for awhile, but supposedly kills the rose. Before burning, be sure to clear the area around the bush of dry or flammable materials and to have some sort of extinguishing equipment nearby.

Biological Control: Biological methods exist to kill or damage multiflora rose. Rose rosette disease, a native virus vectored by a eriophyid mite (*Phyllocoptes frutiphilus*), can be fatal. However, it may infect native roses and plums as well as commercially important members of the rose family like apples, certain berries, and ornamental roses. The disease spreads from

infected canes to the roots and then to other canes. Plants usually die within 1-2 years. Pruning may be practical in areas where the disease is present because it encourages succulent growth, increasing plant susceptibility to mite infestation.

Two insects also feed on multiflora rose. The larva of the rose stem girdler beetle girdles and kills individual canes; the rose seed chalid wasp (*Megastigmus aculeastus* var. *nigroflavus*) reduces seed viability. The U.S Department of Agriculture should be contacted for more information on biological control methods.

Vines:

Roundleaf Bittersweet (Asiatic Bittersweet, Oriental Bittersweet) (*Celastrus orbiculatus*)

Description: Roundleaf bittersweet is a deciduous, woody, perennial vine with round stems sometimes growing up to 4 inches in diameter. Once established at a site, the vine can also send up shoots from its roots. The leaves are glossy and rounded with finely toothed margins, occurring alternately on the stem. Flower clusters emerge at the leaf axils, and fruits are yellow which split to reveal three bright red seeds that remain on the vine through the winter. In late autumn, the leaves turn golden-yellow, and are quite conspicuous.

Similar Species: Climbing or American bittersweet, *Celastrus scandens*, is a native climbing vine. It can be distinguished from Roundleaf bittersweet by its flowers, which occur at the tip of, not along, the stem.

Distribution and Habitat: Roundleaf bittersweet is native to Japan, Korea, and China, and was introduced to North America in the mid-1800's as an ornamental. It now occurs in the eastern US, from New York to North Carolina, and west to Illinois and Wisconsin. It inhabits forest edges, woodlands, hedgerows, and fields, particularly disturbed areas. More often it is found in sunny areas, however its shade tolerance has allowed it to move into forested areas as well.

Life History and Effects of Invasion: Roundleaf bittersweet is typically dioecious, with both male and female plants. In May or June, the flower clusters emerge at the leaf axils of the female plant. These eventually produce the yellow fruits in September that split to reveal the three red seeds. The seeds remain on the vine through the winter, supplying food to birds and small mammals, and receiving widespread seed dispersal in return. In addition, rootsuckering (sending shoots up from the roots), rhizomes (underground stems), and stolons (above-ground stems) allow the plant to grow vegetatively.

Roundleaf bittersweet is an aggressive vine, threatening all vegetation of forest and open areas. It grows on and over other vegetation and trees, strangling and girdling them, and its sheer weight on some trees causes them to uproot. Also, its dense shade prevents photosynthesis for those plants unlucky enough to be under them.

Roundleaf bittersweet is now beginning to hybridize with the native Climbing bittersweet significantly, changing the genetics between the two species.

Controlling Roundleaf Bittersweet

As with all invasive species, roundleaf bittersweet in natural areas is most effectively controlled by recognizing its appearance early and removing isolated plants before they begin to produce seed. With large infestations, the largest seed-producing plants should be removed first.

Mechanical Control: Prescribed burns in early spring or fall may kill seedlings (especially in the first year of growth), and larger stems, although this method has met with mixed results. Burning is preferable for fire-adapted communities and should not be used if it adversely affects a community. Annual or biannual burning may have to be continued for several years to control roundleaf bittersweet, depending on the extent of establishment. It is often difficult to burn in dense stands as the understory is typically well-shaded, allowing little fuel build-up.

In high quality natural areas where the use of chemicals is a concern, small patches of plants up to 0.4 inches in diameter can be pulled when the soil is moist. Larger plants 0.5 inches to 1.5 inches in diameter can be dug or pulled using a weed wrench. Disturbed soil will result from these techniques, and should be tamped down to further seedling development.

It should be noted that cutting stems at any time will likely result in resprouting unless followed by an application of glyphosate herbicide.

Chemical Control: Chemical control methods are best employed during the fall when most native plants are dormant and bittersweet is still actively growing, thus decreasing the risk of affecting nontarget plants. The bittersweet's golden leaves and prominent seeds will also provide easy recognition and allow for a thorough treatment at this time. Control methods can be implemented during the growing season, but with more risk of affecting non-target plants, and the effectiveness of the treatment is generally lower except in late summer and fall. Winter application of chemicals has proven to be successful as well, and further decreases the risk of damaging non-target species.

Cutting stems off near ground level and treating them with glyphosate successfully curbs sprouting. Immediately after cutting, glyphosate should be applied to the stumps; for larger stumps, herbicide application should be directed to the vascular tissue just inside the bark (the phloem). Resprouts should be cut and the stumps treated again, or, if left uncut, treated with a foliar spray of glyphosate solution applied with a hand sprayer. Foliar application of glyphosate herbicide using a backpack sprayer can also be effective, but is best used on areas with large numbers of bittersweet seedlings which need to be treated. Spraying should be done in the

autumn, well before the bittersweet leaves have begun to drop and at a time when temperatures are likely to remain above freezing for a few days. Glyphosate concentrations are generally low for foliar sprays and higher for stump application. Check herbicide labels for accurate dilution rates. Dyes can be added to help identify areas treated.

For severely disturbed sites, a triclopyr solution diluted in water can be applied to freshly cut stumps with a low pressure hand sprayer, a spray bottle, or sponge applicator; a tricolopyr solution formulated for oil dilution can also be effective as a cut stump treatment. Basal bark application of triclopyr solution (formulated for oil dilution) or 2-4-D in diesel fuel may be used to control the roundleaf bittersweet as well. For stems larger than 2 inches, the mixture is most effective when sprayed all the way around the stem; for smaller stems, spraying one side is sufficient. This treatment may not be effective on larger trees.

Forbs:

Dame's Rocket (*Hesperis matronalis*)

Description: Dame's rocket is a showy, short-lived perennial with large, loose clusters of fragrant white, pink, or purple flowers that bloom from May to August; flowering stalks are 2-3 feet in height. Like other members of the mustard family (Brassicaceae), dame's rocket has flowers with four petals. Fruits are long and narrow and contain many seeds. Leaves are oblong, sharply toothed, and arranged alternately, decreasing in size as they ascend the stem. The overwintering rosette is easily identified from fall through spring.

Similar Species: This species is often confused with garden phlox (*Phlox paniculata*). Unlike dame's rocket, phlox species have opposite leaves with entire (not toothed) margins, and flowers with five petals, not four.

Distribution and Habitat: Dame's rocket is native to Eurasia but was introduced to North America in the 1600's. This plant usually grows in moist and mesic woodlands, on woodland edges, along roadsides, and in open areas.

Life History and Effects of Invasion: Dame's rocket is planted as an ornamental, but quickly escapes cultivation because of its prolific seed set. Unfortunately, part of its success can be attributed to its wide distribution in "wildflower" seed mixes. It generally produces a basal rosette the first year of growth, flowering the following year. Dame's rocket is a prolific bloomer and produces large quantities of seed from May to July. A plant may have several clusters of flowers at various stages of development, enabling it to produce both flowers and seeds at the same time. The effects of dame's rocket invasion are not known, but it may compete with native species.

Controlling Dame's Rocket

Dame's rocket has not been studied extensively. In fact, it is not yet widely recognized as an invasive plant in the Midwest. Consequently, this plant may not be recognized as a troublesome species until it is well-established as a formidable problem. Locating and removing plants immediately before seed sets is the best way to prevent the spread of dame's rocket. Be sure to check the contents of "wildflower" seed mixes for this species, and do not plant those that carry it.

Mechanical Methods: Plants in urban gardens may not pose a problem, but any plant whose seed may escape to roadsides or woodlots should be eradicated or prevented from going to seed by cutting the flower heads after they bloom. Pulling may need to be done for several years to remove new plants established from the seed bank. Pulling or use of a dandelion digger is most effective when the soil is moist. If plants are pulled when in bloom, they should not be placed in compost piles, as the seeds may ripen and spread. Flower-heads should be bagged for landfill, or dried and burned where permissible. Where there is sufficient leaf litter or other fuel, burning has been found to be an effective control method.

Chemical Methods: Selectively applying a broadleaf herbicide like glyphosate to seedlings according to label recommendations may be an effective means of control. To avoid damaging native vegetation, apply herbicide in late fall when the rosettes are still green.

Common Teasel *(Dipsacus sylvestris)*
and
Cut-leaved Teasel *(Dipsacus laciniatus)*

Description: Teasels are monocarpic perennials. Each plant grows as a basal rosette for a minimum of one year before sending up a tall, flowering stalk, producing seed, and dying. The length of the rosette stage varies according to the amount of time needed to acquire enough resources for flowering to occur.

During the rosette stage, leaves change from a younger form, in which they are somewhat ovoid in shape, to and older form, when they become large, oblong, and quite hairy. While a rosette, teasel develops a large taproot which may reach a length of over 2 feet and a diameter of up to 1 inch at the crown.

Cut-leaved teasel blooms from July through September, while common teasel blooms from June through October. Flowering plants have upright, prickly stems that bear large, oblong, opposite, sessile leaves; the leaves form cups where they attach to the stem (the cups may actually hold

water) and are prickly, especially on the lower midrib. The leaves of cut-leaved teasel are broader than those of common teasel and have feathering lobes. The unique inflorescence of teasel makes the plant readily identifiable when flowers or seedheads are present; the small flowers are packed in dense, oval-shaped heads subtended by stiff, spiny bracts located terminally on the flowering stems. Cut-leaved teasel usually has white flowers, while common teasel generally has purple flowers. Flowering stems may reach 6-7 feet in height. The two species of exotic teasel may hybridize.

Distribution and Habitat: The common and cut-leaved teasels are European plants introduced to North America in the 1700's. Teasel is currently used in horticultural plantings and dried flower arrangements.

Teasel grows in open, sunny habitats that range from wet to dry. Optimal habitats seem to be mesic, though cut-leaf teasel is more of a problem in wetter sites. Roadsides and disturbed areas are the most common habitats of teasel, although it sometimes spreads to high quality prairies, savannas, seeps, and sedge meadows. Both species have become severe threats to northern Illinois natural areas. Rapid expansion of the range of cut-leaved teasel has been observed in several midwestern states, including southern and western Wisconsin.

Life History and Effects of Invasion: The teasel population has rapidly expanded in the last few years. Movement has been documented along highway systems, where dispersal is aided by mowing equipment. Teasel is an aggressive exotic that can form extensive monocultures.

Teasel produces an abundance of seeds; a single teasel plant can produce over 2,000 seeds, of which 30-80% may germinate. (The head of cut-leaved teasel need not even be fully mature in order to produce viable seed.) Seeds remain viable for at least 2 years. Although seeds typically don't disperse far--most seedlings are located near the parent plant-- highway mowing equipment and inappropriate disposal of dried teasel heads from flower arrangements can increase the extent of spread, as can dispersal by water. After death, adult plants leave behind a relatively large area of bare ground formerly occupied by their own basal leaves; this ground provides an optimal nursery site that new plants readily occupy.

Controlling Exotic Teasels

Mechanical Control: Cutting, digging, and burning are recommended as the best solutions for control in natural areas. For small infestations, rosettes can be dug up using a dandelion digger; as much of the root as possible must be removed to prevent resprouting. Cutting with a sharp spade or shovel below the surface of the soil can be helpful, but the area should be checked later for resprouts. As an alternative, the stalks of flowering plants can be cut just before flowering. The plant should not reflower, but instead die at the end of the growing season. Cut flowering stalks should be removed from the natural area if the flowers have opened, because seeds can mature even after cutting. Cutting the flowering stalk before the full bud stage should be avoided because the plant will usually send up new flowering stalks. Cutting flowering stems may need to be repeated for several years to control teasel. Teasel in nearby areas should also be eliminated to prevent introduction of new seed.

Late spring burns can be useful in controlling teasel before it becomes dense, but burning should be employed with other methods to insure maximum control. Burning a site in the spring so that basal rosettes are visible amidst blackened soil and grasses may aid in manual or chemical control of teasel.

Chemical Control: Both triclopyr and glyphosate can be used to control teasel, although triclopyr is appearently the more effective of the two herbicides. Triclopyr is dicot-specific and can be applied to foliage and stems during the growing season, preferably before the plant has bolted (sent up a flowering stalk) Glyphosate is also effective when applied to foliage and stems before bolting, although it is non-selective. Herbicide can be applied after bolting, but seed development remains a risk. The rosettes of teasel remain green late into the fall, after most other plants have become dormant; application at this time reduces the risk of harming non-target species. Glyphosate may also be effective during the dormant season, providing the rosettes are photosynthesizing when glyphosate is applied.

Poison Ivy (*Toxicodendron radicans*)

Description: Poison ivy is a plant of variable habit, occurring either as a vine--climbing the trunks of trees or growing along the ground--or as an upright shrub. Its glossy compound leaves sport three leaflets which may be highly variable in appearance, even when borne on the same plant; the leaflets may have toothed, lobed, or entire margins. The arrangement of leaflets on each leaf is diagnostic of poison ivy: the middle leaflet extends from a long petiole, the base of which is flanked by two lateral leaflets. Foliage often conceals the minute inflorescences during flowering; flowers arise from leafless lateral branches in clusters of up to 25, giving way to yellowish-white berries in the fall. Aerial roots are usually associated with poison ivy, especially in its viney form. Since these roots cling to trees summer and winter, identification of dormant plants is possible; prominent leaf scars which occur alternately on the vine can be used to distinguish poison ivy during the winter months.

Distribution and Habitat: Found mainly in the eastern half of the United States, poison ivy is common in open woodlands and river bottom forests, preferring to climb trees in disturbed habitats. The plant may also grow unsupported in open sites.

Life History and Effects of Invasion: Poison ivy blooms from early to mid-summer, its bunches of small, off-white flowers maturing into clusters of berries.

Poison ivy is generally not harmful to other native flora. Oils from the leaves and stems are, however, irritating to humans. Smoke from burning poison ivy is also dangerous. Because this species prefers disturbed areas, it is commonly found in many human-altered environments, including trails, parks, yards, and recreation areas.

Control Methods for Poison Ivy

Caution: Exposure of the skin to poison ivy will often result in contact dermatitis, so protective clothing (including gloves and long sleeves) should be worn when control methods are being implemented. Since the irritating oils produced by the plant can remain on clothing for a year or more, all clothing should be thoroughly washed before being used again.

Mechanical Methods: Uprooting individual plants is a common method of control. This is most safely done in late autumn, either before or after the leaves have fallen. When pulling, remove the entire root to avoid resprouting. Once dry, plants should be disposed of in the trash, along with the gloves used to pull them. Plants should never be disposed of by composting or burning; the former may result in resprouting, the latter in the release of fumes which can cause severe irritation of the lungs and throat. Pulling must be repeated for several years in order to deplete the seed bank.

Regular prescribed burning can be employed to control poison ivy in grasslands, although care should be taken to stay upwind from smoke given off by the fire.

Chemical Methods: Poison ivy can be controlled in late spring or early summer using herbicides. Glyphosate or 2,4-D can be applied at label-recommended rates to the foliage with a sponge or sprayer. This procedure also must be repeated for several years to deplete the roots and seed bank.

Knapweeds (*Centaurea* spp.)

Species and Descriptions: Several *Centaurea* species occur in our area. These include:

- Russian knapweed (*Centaurea repens*): found in disturbed areas, but rarer in Wisconsin.
- Bachelor's button (*C. cyanus*): currently in cultivation and common in "wildflower" mixes; with blue flowers generally larger than *C. maculosa*.
- White-flowered knapweed (*C. diffusa*): found in disturbed areas; generally with white flowers, but easily confused with *C. maculosa*.
- Brown knapweed (*C. jacea*): stems are branched from the base of the plant, and lower leaves taper at both ends, whereas the upper leaves are sessile, sometimes with a lobed base.
- Yellow Starthistle (*C. solstitialis*): similar to the other knapweeds, but with bright yellow flowers.

Distribution and Habitat: While all the knapweeds like open habitats with full sun, their exact distribution is unknown in Wisconsin aside from a few minor infestations. If individual or groups of these knapweed species are found, the DNR's Bureau of Endangered Resources should be contacted.

Life History and Effects of Invasion: Because of our limited knowledge of these other knapweed species in Wisconsin, exact life histories are not known. It should be cautioned, however, that large populations of knapweeds may exist, and many of these species may have the capacity and potential for explosive growth given the right conditions.

Controlling Knapweeds

Prevention is extremely important, as it is believed knapweed species have the potential to spread rapidly. Control methods should be similar to those of the spotted knapweed, and it is recommended they be extended to the other knapweed species as well.

Ox-eye Daisy *(Chrysanthemum leucanthemum)*

Description: The ox-eye daisy is an attractive plant growing from a rhizome with a basal rosette of leaves. Stems producing flowers grow 1 – 3 feet in height from the rosette, and terminate in single 1 – 2 inch flowers of 20-30 white petals each. Stems are hairless, and mostly unbranched except for minimal branching possible near the top. Leaves are also hairless, alternate on the stem, and have about 12 teeth and rounded lobes on the margins. Upper leaves are narrower than basal rosette leaves, which may grow to 6 inches in length.

Distribution and Habitat: The ox-eye daisy grows throughout most of the US and Wisconsin as an introduction from Eurasia. It tolerates a wide variety of soil types except wetlands, but does

not usually exist on cultivated sites. It is primarily naturalized in sandy and poor soils.

Life History and Effects of Invasion: Flowering occurs from June to July. The ox-eye daisy has the potential to dominate sites at the expense of community diversity.

Controlling Ox-eye Daisy

Mechanical Control: The most effective control is early detection and removal of pioneering plants. Small populations can be removed by digging or pulling. This is best done where the soil is moist. The entire root should be removed. Mowing has not been successful--plants merely reflower at a lower height.

Once established, ox-eye daisy may be reduced by hot prescribed burns. These can be followed by selective pulling and digging once the population has been decreased. Annual burns have reduced populations anywhere from five to ninety percent. Reductions seem to correlate to the intensity of the burn administered; burns that remove nearly all the duff are most effective. Following a burn, reseed with native species. The potential effects of intense burning on native species must be taken into consideration when planning a burn.

Biological Control: Several biological controls exist, including two root mining moths, a flower moth, and a root mining beetle. These have met with varying degrees of success. Most promising are the two seed-head attacking flies *Urophora affinis* and *U. quadrifasciata*. Congruently, these two flies have reduced seed production 95% in experimental populations. While both flies are being released experimentally in Wisconsin, their effectiveness here is still unknown, and there are concerns they may impact rare composits. These insects were not available for general use at the time of printing. The USDA should be consulted to determine the current status of these controls.

Chemical Control: Chemical controls are an effective means of eliminating ox-eye daisy, but they may also have the most adverse consequences. The recommendations from western rangelands involve the use of some very potent chemicals. These restricted chemicals are not recommended for use on high-quality natural areas, but may be appropriate on roadsides and other highly disturbed areas. Experimentation testing the effectiveness of less toxic broad-leaf herbicides such as triclopyr or glyphosate is encouraged.

A solution of triclopyr in the water-soluble formulation with dye can be used to kill plants. Triclopyr should be sprayed on the entire plant except the flower, which should be spared for native fauna. This application should be repeated 3-4 times per year for two years. Triclopyr will not affect grasses.

Picloram will control plants and seedlings for 2-3 years, although the residual control period may be shorter on gravel soil--where soil organic matter is high--or in wet areas. Picloram should be

applied either in fall when the plant is in the rosette growth stage, or in spring during the bud to bloom stage. Picloram should not be used near water or on sandy soils with ground water ten feet or less below the surface.

Dicamba also controls ox-eye daisy, but may require annual follow-up treatment for a minimum of two years. Clopyralid is more selective, affecting only legumes and composites. A mixture of clopyralid plus 2,4-D is also an option; both herbicides provide good control of ox-eye daisy with less soil residual than picloram or dicamba. *However, the herbicide clopyralid also has deleterious effects on lupine at all life stages; its application must be closely monitored.* Plants that are still in the rosette stage can be controlled by applying a 2,4-D low volatile ester, oil soluble amine, or water soluble amine formulation. Annual spraying for several years may be required to deplete the seed bank.

Transline® is an herbicide selective for legumes and composites. It is best applied in pre- or early bud stage, but is effective even when plants are in seed. Follow label recommendations for proper application methods and concentrations.

Picloram and clopyralid are the most commonly used and effective herbicides for ox-eye daisy. Again, clopyralid must be used with care because of its negative effects on lupine. Picloram causes the largest initial decrease in native forb cover, but the experiment that produced this data also concluded that most non-target forb populations were tolerant of herbicidal treatments and benefited from being released from daisy competition after three years of selective herbicidal application. Application of these herbicides has not been found to decrease the frequency of occurrence of grasses, sedges, shrubs, or trees in the treated site.

Queen Anne's Lace (Wild Carrot) (*Daucus carota*)

Description: A biennial with a basal rosette of leaves its first year and an erect flowering stalk exceeding 3 feet the second. The fern-like leaves are primarily basal, with only a few alternate, sessile leaves on the stem. Leaves are triangular or oblong, bipinnately compound, up to 6 inches long, and have a carrot-like odor to them. The second-year flowering stems are hollow, vertically ribbed, and hairy. Small, white flowers occur on twice-branched stalks altogether terminating in a flat-topped cluster resembling lace. There is usually a single purple flower in the center of the flower cluster. Flower clusters may close at maturity, bending inwards to resemble a bird's nest. Seedlings resemble parsley, with 3 – lobed leaves deeply pinnate. Queen Anne's lace also has a single yellowish-white taproot with several smaller secondary roots.

Distribution and Habitat: Queen Anne's lace is a widespread weed, most commonly occurring on well-drained to dry soils, especially in old meadows, fallow fields, disturbed areas, and invading open woods. Roadsides, and other habitats. Introduced from Eurasia, it has become one

of our most persistent weeds in disturbed areas.

Life History and Effects of Invasion: The basal rosette of the first year plant will remain green through the winter. Second year flowering plants may produce up to 4000 seeds, the main mode of reproduction. After the second year, plants die, but stems and leaf remnants may remain. Queen Anne's lace slowly invades an area in waves following initial infestation. Once its population builds, the plant spreads rapidly. An aggressive weed, Queen Anne's lace frequently invades and modifies a variety of open habitats.

Controlling Queen Anne's Lace

Mechanical Control: The best way to control Queen Anne's lace is through early detection and eradication. Small populations can be effectively controlled by cutting the entire root of each plant just below ground level with a sharp shovel or spade (cutting below ground level prevents resprouting). In some soil types under wet conditions, plants can be pulled out of the ground by hand. When controlling it by cutting or pulling, all seeds must be removed from the site and disposed of in a landfill or by burning to help prevent new plants from sprouting.

If the population is too large to hand-cut or pull, a mower can be used just before peak flowering and before the seeds set. Plants may resprout when cut above the ground, and should be cut again several weeks later to prevent flowering. Cutting may also be done after seed set, greatly reducing the likelihood that plants will be able to resprout and flower; plants cut at this time must be gathered and removed from the site to prevent mature seed from developing and falling to the ground. The potential for reseeding can also be eliminated by hand-collecting all seeds after they have set. If control methods for flowering or seeding plants are carried out over several years, the population of Queen Anne's lace will decrease as the seed bank is depleted.

Burning does not seem to impact Queen Anne's lace, as plants quickly resprout following a fire. However, their rosettes are easy to recognize on the darkened soil left by burning and can be eradicated by hand-digging. Prescribed burning stimulates increased growth in prairie species, especially grasses, whose spread will eventually outcompete Queen Anne's Lace populations.

Chemical Control: Chemical controls are effective, but should be used sparingly on quality natural areas. The best method is to burn the site then follow with spot application of glyphosate, as Queen Anne's lace is one of the first plants to green after a burn. Glyphosate can be spot applied to the basal rosette with little effect on dormant species.

Cypress Spurge (Cemetary Spurge) (*Euphorbia cyparrissias*)

Description: Cypress spurge is a member of the spurge family (Euphorbiaceae), ranging up to 12 inches in height. The erect stems of this plant support alternate, linear, apetiolate leaves of a

bluish-green hue. In contrast to leafy spurge, *Euphorbia esula*, leaves are narrower, up to 1 inch long by less than 1/8 inch wide, and much more numerous on the stem. When in bloom, the plant bears multiple yellow-green inflorescences arranged in an umbel near the top of the stem; to the casual observer, each of these condensed inflorescences may appear to be only a single flower. The yellow-green bracts which subtend each inflorescence are the most colorful and conspicuous part of the plant. Leaves eventually overtop the inflorescence, another distinguishing feature from the leafy spurge. A milky white sap is present in all parts of the plant, and aids in identification, although this sap is present in all species of *Euphorbia*.

Distribution and Habitat: Cypress spurge is a deep-rooted Eurasian perennial that is adapted to a wide range of conditions. It occurs primarily in non-cropland habitats, including roadsides, prairies, savannas, and woodlands and is tolerant of a wide range of substrates, from damp to very dry soils. In Wisconsin, it has been found invading some dry grasslands in western Wisconsin to mesic savannas in the southeast. Historically, cypress spurge was widely used in cemeteries and gardens early in the 1900s and may persist or have escaped from these areas.

Life History and Effects of Invasion: Cypress spurge possesses multiple characteristics which serve to make it an aggressive competitor, spreading rapidly to crowd out desirable species. It appears that the plant is allelopathic, producing chemicals to impede the growth of competing species. It also forms hybrids readily, the hybrids of *E. cyparissias*, *E. esula*, and other spurge species often collectively referred to by the common name "leafy spurge." The plant produces dense stands of up to 1,800 stems per square yard and has a deep root system composed of woody, tough roots which can reach depths up to 15 feet and spread laterally up to 35 feet, making eradication extremely difficult. Vegetative reproduction from both crown and root buds contributes to the persistence of the weed; even if the foliage of the plant is destroyed, the roots will regenerate new shoots.

Cypress and leafy spurge can be catastrophic to grasslands for both economic and ecological reasons. It is estimated that the plant can reduce the productivity of grazing land by 50 to 75 percent, out-competing other vegetation by shading competitors and sequestering available moisture and nutrients. In natural areas, cypress spurge reduces species diversity and habitat for wildlife, and has the ability to displace native grasses and forbs.

Controlling Cypress Spurge

Due to the similarity of species, control recommendations for leafy spurge (*Euphorbia esula*) should also be effective against cypress spurge.

St. John's Wort *(Hypericum perforatum)*

Description: A perennial forb growing to 2½ feet, St. John's wort has numerous, leafy branches off its main stem. Leaves are linear to oblong, growing from 1 to 2 inches on the main stem and

shorter on branches. Branches are sharply ridged below the base of each leaf. Flowers are numerous, up to 1 inch wide with 5 bright yellow petals with black dots around the margins. Styles in the flower number 3, with 3 groups of many stamens. Flowers occur in branched terminal clusters.

Distribution and Habitat: Originally from Europe, St. John's wort has become a thoroughly naturalized weed. It occurs in dry pastures, old fields, roadsides, and other dry habitats in full sun.

Life History and Effects of Invasion: St. John's wort often attains high densities on dry, sunny wild lands, even ones undisturbed by human or livestock activity. It tends to dominate sites at the expense of community diversity or forage production, and can also increase surface run-off and sedimentation. Light-skinned cattle can be poisoned by feeding on St. John's wort. Sites grazed by cattle or horses can be heavily infested as they selectively graze around it.

Controlling St. John's Wort

Mechanical Control: The most effective control is early detection and removal of pioneering plants. Small populations can be removed by digging or pulling. This is best done where the soil is moist. The entire root should be removed. Mowing has not been successful--plants merely reflower at a lower height.

Once established, St. John's wort may be reduced by hot prescribed burns. These can be followed by selective pulling and digging once the population has been decreased. Annual burns have reduced populations anywhere from five to ninety percent. Reductions seem to correlate to the intensity of the burn administered; burns that remove nearly all the duff are most effective. Following a burn, reseed with native species.

Chemical Control: Chemical controls are an effective means of eliminating St. John's wort, but they may also have the most adverse consequences. The recommendations from western rangelands involve the use of some very potent chemicals. These restricted chemicals are not recommended for use on quality natural areas, but may be appropriate on roadsides and other highly disturbed areas. Experimentation testing the effectiveness of less toxic herbicides such as triclopyr or glyphosate is encouraged.

A solution of triclopyr in the water-soluble formulation with dye can be used to kill plants. This application should be repeated 3-4 times per year for two years. Triclopyr will not affect grasses.

Picloram will control St. John's wort plants and seedlings for 2-3 years, although the residual control period may be shorter on gravel soil, where soil organic matter is high, or in wet areas.

Picloram should be applied either in fall when the plant is in the rosette growth stage, or in spring during the bud to bloom stage. It is most effective when applied in the pre- to early bud stage. Picloram should not be used near water or on sandy soils with ground water ten feet or less below the surface.

Dicamba also controls the plants, but may require annual follow-up treatment for a minimum of two years, and annual spraying for several years may be required to deplete the seed bank.

Bird's Foot Trefoil (*Lotus corniculatus*)

Description: Bird's foot trefoil is a low, mat-forming perennial legume that forms colonies from rhizomes and stolons (below- and above-ground horizontal stems). Stems, with or without hairs, are square at the top and rounded near the base and may become woody with age. Its leaves are compound, with the terminal leaflets numbering three, giving the plant a general resemblance to clover. Leaflets generally have smooth edges and are oval with a pointed end, measuring up to ¾ of an inch by 3/8 inch.

Flowers of the bird's foot trefoil are produced in branched clusters with 2 – 6 flowers at the end of a stalk measuring 1 – 4 inches in length. Flowers are bright yellow, sometimes reddish, coppery, or with red streaks. Fruiting bodies are 1 inch long and resemble small pea pods. They are attached to the stalk at one end and spread out radially, giving the resemblance of a bird's foot, thus, the plant's common name.

Distribution and Habitat: Bird's foot trefoil is found throughout the US, and is common in the northeast and southern Canada. It easily escapes into the wild from cultivation as a forage crop and roadside plantings. It is tolerant of a wide variety of soil types, including sandy and gravely types, and so is an indicator of poor, dry soils. It can become a persistent weed in these areas and in meadows, old fields, and roadsides.

Life History and Effects of Invasion: Flowers are produced in late June through the fall. Seeds produced most often germinate in the spring, though some will germinate in the fall. Seedlings of the bird's foot trefoil are rarely seen, but most of the above-ground growth of the plant occurs in the spring. Rhizomes grow mostly in the fall, as do new shoots. Once established, the plant crawls over and smothers other vegetation.

Controlling Bird's Foot Trefoil

A limited number of control measures have been gleaned for this species, and further field research is needed to adequately address the bird's foot trefoil. However, preventative measures can and should be implemented. Do not use this plant for erosion control. Encourage your local highway department to stop using it and replace it with less invasive species for roadside use.

Mechanical Methods: In fire-adapted communities, prescribed burning in late spring can be an effective control. Burns may need to be repeated for several years to achieve adequate control and deplete the seed bank.

Where feasible, late spring mowing for several successive years can control this species. Another technique is to mow twice every year—in June and in late August—corresponding with successive leaf-out periods.

Chemical Control: The herbicide 2,4-D amine (dimethylamine salt of 2,4--D) is a low volatility formulation that can be foliar-applied in early spring when bird's foot trefoil is growing actively above ground. 2,4-D amine should be applied by hand sprayer at the label-recommended application rate for spot application. Phenoxy herbicides are broadleaf-selective plant growth regulators that will not harm grasses, but precautions must be taken in the vicinity of non-target broad-leaved plants. To reduce vapor drift, use an amine rather than an ester formulation of 2,4-D.

A solution of triclopyr in water has also been successful in controlling large infestations. Like 2,4-D, triclopyr is advantageous because it is dicot-specific and does not affect grasses beyond some temporary browning.

Glyphosate is a broad-spectrum, translocated herbicide that can be foliar-applied as a solution during early spring when bird's foot trefoil is actively growing. Glyphosate is nonselective, and care should be taken to avoid non-target plants. To insure good foliar coverage, the previous year's growth should be burned to eliminate duff accumulation and to expose new growth. A follow-up application of glyphosate may be necessary the following fall or early spring to combat regeneration from underground parts or seed.

The herbicide clopyralid has been used successfully to treat roadside populations of bird's foot trefoil. This herbicide shows promise because it is even more specific than triclopyr in the plant families it affects; specifically, this herbicide kills leguminous species and composites, but does not affect grasses and most other plant families. It is best applied in pre- or early bud stage, but is effective even when plants are in seed. *However, the herbicide clopyralid also has deleterious effects on lupine at all life stages; its application must be closely monitored.*

When applying any of the herbicides described above, spot applications should be done uniformly with a hand sprayer to ensure that the entire leaf is wetted. Do not spray so heavily that herbicide drips off the target species. Native plants, left unharmed, will be important in recolonizing the site after trefoil is controlled. Reseeding of native plants may be necessary where infestations of trefoil are severe. Planting an intermediate cover crop may be appropriate.

All of these methods may need repeated applications over several years to effectively eradicate

populations of bird's foot trefoil that are well established; thus, regular monitoring of treated areas will be necessary.

Field Sorrel (Sheep Sorrel, Red Sorrel) *(Rumex acetosella)*

Description: Growing up to 16 inches tall, field sorrel is a perennial growing from a rhizome with leaves primarily in a basal rosette. Mature leaves are arrowhead-shaped, with 2 spreading lobes at the base of the widest part of the leaf, smooth, and are 1-3 inches in length. Leaves growing off the flowering stem are alternate, smaller, linear, and may not have the 2 lobes. Leaves often turn yellow in the fall. Stems may be several in number, branching at the top, 4 – sided, with vertical ridges, and maroon in color near the base. Numerous thin rhizomes grow from a single yellow taproot.

Flowers occur in branched clusters at the top of the stalk. Field sorrel is dioecious, so male and female flowers are on different plants. Female flowers are reddish brown, small, and durable. Male flowers are yellowish green.

Field sorrel is distinguished most from its unique leaf shape and its sour taste, acquired from the accumulation of oxalates in the plant.

Distribution and Habitat: Widely found throughout the US and southern Canada, it is usually found on acid soils, areas of poor drainage, low nitrogen, and little plant competition, though it is also found in turfgrass and nursery crops.

Life History and Effects of Invasion: Flowers are produced May through September, and may persist after the seeds have formed. Seedlings grow into a basal rosette of oval or egg (not arrowhead) shaped leaves. Shoots from rhizomes are generally larger and have more leaves. Both seedlings have smooth leaves with waxy granules covering them. The arrowhead shaped leaves then occur after the 2^{nd}, 3^{rd}, or 4^{th} leaves develop.

Controlling Field Sorrel

A limited number of control measures have been gleaned for this species, and further field research is needed to adequately address field sorrel. However, preventative measures can and should be implemented. Difficulties are encountered when large colonies of field sorrel exist on high-quality native habitat, and burning may be one of few control techniques. Herbicide application is not recommended in these situations as the potential negative impacts to native vegetation and habitats may be too great.

Mechanical Methods: Once established, field sorrel may be reduced by hot prescribed burns. Burns that remove nearly all the duff are most effective. Following a burn, reseed with native species.

Yellow Rocket (*Barbarea vulgaris*)

Description: Yellow rocket may be a winter annual, biennial, or occasionally a perennial growing 1 to 3 feet in height from a single taproot. A multitude of stems branch up from a basal rosette of deep green leaves which are thick, 2 – 5 inches long, and may persist through winter. Leaves on the lower stem and basal rosette are lobed, with lateral lobes opposite and one larger terminal lobe that has a unique heart-shaped base. Leaves on the stem are alternate and get smaller, to about 1 inch, as they progress up the stem.

Flower stems are branched or singular at the top. Flowers are bright yellow, forming pyramid-shaped terminal clusters at the end of the stems. Flowers have 4 petals and 6 stamens. Yellow rocket fruits are very long compared to their width, 1 inch long to 1/16 inch wide, and many branch off the flower stem at maturity. Seedlings have rounded leaves that may be heart-shaped at the base, and have a long petiole. Margins of seedling leaves may be wavy, and become toothed with age.

Distribution and Habitat: Yellow rocket is common in the eastern and central US. It most commonly occurs on nutrient-rich sandy and loamy soils of disturbed agricultural lands, but also along roadsides.

Life History and Effects of Invasion: Reproduction is by seed, produced from May through June and germinating in the spring or fall. Plants may produce 1000 to 10,000 seeds which remain viable in the soil for several years. The basal rosette of seedlings persists through the first year. Flowers are produced on stems the second year, appearing in early spring (April to June), and then intermittently through the summer.

Plants will survive as perennials provided there is adequate moisture during the summer, otherwise they will die after fruiting in drought years.

Controlling Yellow Rocket

A limited number of control measures have been gleaned for yellow rocket, and further field research is needed to adequately address it. However, preventative measures can and should be implemented. Difficulties are encountered when large colonies of yellow rocket exist on high-quality native habitat, and burning may be one of few control techniques. Herbicide application is not recommended in these situations as the potential negative impacts to native vegetation and habitats may be too great.

Mechanical Methods: Once established, yellow rocket may be reduced by hot prescribed burns. Burns that remove nearly all the duff are most effective. Following a burn, reseed with native species. In agricultural situations, tilling the soil will often control yellow rocket.

Hawk's Beard (Narrowleaf Hawk's Beard) (*Crepis tectorum*)

Description: An annual or winter annual with a large taproot, hawk's beard grows to 20 inches in height. Basal leaves are flimsy, smooth, 6 inches by 1 inch wide, with toothed or rough edges and a milky sap. Upper leaves are mostly linear in shape. Several yellow flower heads, measuring up to 1 inch and resembling dandelion, top stalks growing up from the basal rosette.

Distribution and Habitat: Found on drier habitats, hawk's beard is distributed in patches throughout the northern US.

Life History and Effects of Invasion: Hawk's beard plants emerge from mid-May to mid-June and from early August to mid-September. The early plants develop as annuals and the later develop as winter annuals. Sporadic emergence occurs at other times. Main reproduction is by seed. Annuals flower from early July through August, and winter annuals flower the year after emergence between mid-June and mid-July.

Controlling Hawk's Beard

Mechanical Methods: Any plant whose seed may escape to roadsides or woodlots should be eradicated or prevented from going to seed by cutting the flower heads after they bloom. Pulling may need to be done for several years to remove new plants established from the seed bank. Pulling or use of a dandelion digger is most effective when the soil is moist. If plants are pulled when in bloom, they should not be placed in compost piles, as the seeds may ripen and spread. Flower-heads should be bagged for landfill, or dried and burned where permissible. Where there is sufficient leaf litter or other fuel, burning has been found to be an effective control method.

Chemical Methods: Selectively applying an herbicide like glyphosate to seedlings according to

label recommendations may be an effective means of control. To avoid damaging native vegetation, apply herbicide in late fall when the rosettes are still green. After application, the seeds of native plants should be sown to provide competition against hawk's beard.

Hairy Vetch (*Vicia villosa*)

Description: A summer or winter annual, or biennial, hairy vetch is a vine-like forb that grows to form a mat, sometimes choking out other species. Its stem is hairy, may grow to several feet in length, and may turn woody with age. Leaves are alternate and compound, with opposite leaflets and a twisting tendril in place of a terminal leaflet. Leaflets are narrowly oblong or linear-lanceolate, up to an inch long, and with 5 – 10 pairs per leaf. Reddish-purple to violet flowers number 10 – 14 (and up to 30) and dangle off a stalk. The somewhat trumpet-shaped flowers then give rise to seed pods (resembling pea pods) about an inch long. Roots are branched and fibrous.

Distribution and Habitat: Found throughout the northern US to California, and southern Canada, hairy vetch invades waste areas, old fields, meadows, roadsides, and also agricultural areas. It is often found on drier soils, including sandy or gravely soils.

Life History and Effects of Invasion: Hairy vetch flowers from June to August. In winter, it may leave a tangled web of dead, brown stems, effectively blocking other plants from growing.

Controlling Hairy Vetch

Very little information is currently available regarding the control of hairy vetch. Research has largely been restricted to the establishment and management of this perennial legume. As a result, a limited number of control measures have been gleaned from the unpublished notes of active natural resource managers. Further field research is needed to adequately address this species, however, preventative measures can and should be implemented. For specific control methods, recommendations for the crown vetch should also be effective against hairy vetch. Do not use hairy vetch for erosion control in areas near native remnants or plantings, and encourage your local highway department to stop using it and replace it with less invasive species for roadside use.

Tansy *(Tanacetum vulgare)*

Description: A traditional flower garden perennial with a robust, invasive rhizome, the tansy has deep green, ruffled and curled leaves measuring 6 inches in length. Like a fern, the leaves are divided almost to the center of the leaf into lobes which number about 7 pairs, which are then divided into smaller lobes with serrated edges. The stem is stout, may be reddish, and branches near the top of its possible 3-foot height. Flowers are yellow and button-like, flat on top, and grow in clusters at the apex of the branched stems. Tansy is strong-scented, and produces a volatile oil which is poisonous.

Distribution and Habitat: The tansy is found extensively, from roadsides, fields and meadows, railroads, and vacant lots to farmyards, dumps, and other waste places. It prefers full sun and well-drained (drier) soils. Introduced from Europe by at least the middle of the 1800s, in Wisconsin it is now more of a problem in central and northern Wisconsin than in the southern portions of the state.

Life History and Effects of Invasion: Flowers occur in late summer, from July through September. Tansy has been planted as an ornamental, but can quickly escape cultivation and form small colonies. Unfortunately, part of its success can be attributed to its appeal in old-fashioned gardens. The tansy is a prolific bloomer and produces large quantities of seed from May to July. A plant may have several clusters of flowers at various stages of development, enabling it to produce both flowers and seeds at the same time. The effects of a tansy invasion are not known, but it may compete with native species.

Controlling Tansy

The tansy has not been studied extensively. In fact, it is not yet widely recognized as an invasive plant in the Midwest. Consequently, this plant may not be recognized as a troublesome species until it is well-established as a formidable problem. Locating and removing plants immediately before seed sets is the best way to prevent its spread. Be sure to check the contents of "wildflower" seed mixes for this species, and do not plant those that carry it.

Mechanical Methods: Plants in urban gardens may not pose a problem, but any plant whose seed may escape to roadsides or grasslands should be eradicated or prevented from going to seed by cutting the flower heads just before they bloom. Pulling may need to be done for several years to remove new plants established from the seed bank. Pulling or use of a dandelion digger is most effective when the soil is moist. If plants are pulled when in bloom, they should not be placed in compost piles, as the seeds may ripen and spread. Flower-heads should be bagged for landfill, or dried and burned where permissible. Where there is sufficient leaf litter or other fuel, burning has been found to be an effective control method.

Chemical Methods: Selectively applying an herbicide like glyphosate or clopyralid to seedlings

or mature plants according to label recommendations may be an effective means of control. To avoid damaging native vegetation, apply herbicide in late fall when the rosettes are still green. Again, clopyralid must be used with care due to the effects it also has on lupine.

Grasses:

Quackgrass (*Agropyron repens* or *Elytrigia repens*)

Description: A grass growing from a rhizome, quackgrass is a perennial that can grow to almost 4 feet, but tolerates mowing. Leaf blades are 1½ to 12 inches long and 1/8 to 3/8 inches wide, flat, smooth on the lower surface, and may be hairy on the upper surface. Leaves are rolled in the bud, and auricles are present where the blade meets the rolled sheath, an area that is white with prominent veins. Sheaths may also be hairy or smooth.

Distribution and Habitat: Found all across Wisconsin, quackgrass is an agricultural weed, as well as of turf, nurseries, waste areas, roadsides, and fields. It can occur on rich loams to dry, nutrient-poor soils.

Life History and Effects of Invasion: Reproduction is by seeds and long underground rhizomes with sharp tips. Quackgrass flowers in June and July, sending up a long spike (2 – 7 inches) with ¼ to ½ inch spikelets arranged alternately in 2 rows. Awns, small hairs extending off the spikelets, may be up to 3/8 inch long. Quackgrass remains green through winter.

Brome Grass (Smooth Brome, Hungarian Brome) (*Bromus inermis*)

Description: A long lived perennial, brome grass grows from a culm with many spreading rhizomes that may send roots 3 feet or more into the soil. Plants grow to 4 feet in height with smooth, flat leaves ½ inch wide and up to 15 inches long. The base of the leaf has an irregularly rounded ligule, and the leaf sheaths are fused around the stem. Flowering branches flare upward and outward after flowering, and are 4 to 8 inches long. Spikelets may be slightly flattened and contain 5 to 10 florets which turn brown at maturity.

Distribution and Habitat: Introduced from Eurasia in the 1880s, varieties of brome grass are found throughout the US, with both southern and northern strains present. In Wisconsin, the northern strains have been used for pasture grass and hay on fertile soils. Brome grass fares best on silty or clayey soils, and is not suited for very sandy soils. The species is both drought and flood tolerant.

Life History and Effects of Invasion: Due to its strong root growth, brome grass has been used for soil conservation practices in the past but has become problematic in some areas. The species

grows vigorously throughout the summer until the seedheads are produced, at which time growth slows. Regeneration is primarily through its rhizomes and seeds.

Timothy *(Phleum pratense)*

Description: A perennial, timothy has grayish green leaves, an enlarged bulbous base, and grows in clumps over 3 feet tall. Leaves are rolled in the bud, and a toothed ligule is present where the blade meets the sheath, which is fused around the stem. Leaves are hairless with rough margins, and taper to a sharp point. Blades are ¼ to 3/8 inch wide and up to 9 inches long. Timothy's stem lacks hairs and is whitish in color.

The seedhead of timothy is distinctive. It is cylindrical, dense, stiff and bristly, and grows to 4 inches in length atop a leafless stalk that may be several feet in length.

Distribution and Habitat: Originally a native of Eurasia, timothy has become a widely naturalized species throughout much of the US and Canada. It is cultivated for hay but occurs as a weed in agricultural and forage crops, and nurseries. Timothy also occurs in old fields, but generally requires nutrient-rich soils.

Life History and Effects of Invasion: Flowers are produced from June to July, and propogation is primarily by seed. Some growth is attributed to rhizomes at the base of the plant, as well as stolons (horizontal stems above ground), which are rarer still.

Tickle Grass *(Agrostis hyemalis)*

Description: Tickle grass is a wispy plant whose flowering branches occupy most of the height of the plant. A native perennial, its leaves are at the base of the plant, less than ¼ inch wide, flat or rolled, and may be rough to the touch. Flowering branches are threadlike and spreading, with flowers at their ends. Spikelets are often purple, turning brown late in the season, and up to ¼ inch long.

Distribution and Habitat: Tickle grass is found across the Midwest, commonly in drier, sandy habitats, but may also occur in wetland areas.

Life History: Tickle grass flowers June to August.

Controlling the Grasses

Mechanical Control: A controlled fire can dramatically reduce the grass population in a native or planted prairie, savanna, or barrens. Fire will also set back the woody species whose shade encourages the proliferation of cool-season grasses. Observing the growth of nonnative grasses is essential for effective control by burning, as timing of burns may need to be changed on a year-to-year basis depending on weather conditions that help or hinder their growth. In southern Wisconsin, a late April or early May burn will generally hinder the growth of new grasses. Burning at this time not only kills new growth but removes the moisture-retaining blanket of leaf litter, increasing stress on nonnative grasses by exposing the darkened soil surface to the sun. Burning further reduces the competitive ability of these grasses by encouraging summer dormancy, thereby decreasing the chance of flowering and seed production. The effect is most pronounced on dry prairies and barrens, where burning can reduce nonnative grass populations by more than 90% (it is rarely 100% effective). Burning at the right time also improves the competitive advantage of native, warm-season grasses and forbs, as later-emerging native species benefit from the elimination of duff and production of a darkened soil surface. It should be noted, however, that burning at this time may negatively affect lupine phenology and may remove the plant's nectar, essential for the Karner blue.

When converting areas dominated by cool-season grasses into prairie, it is helpful to reduce the grass cover and seed bank before planting native seeds. This can be accomplished by any combination of tilling, smothering the grass, or applying herbicide. Till several times a year for at least one season to expose the seed bank and prevent further growth of the grass sod. Herbicide use followed by a season of tilling may also be effective in controlling nonnative species. On small sites, grasses can be killed by covering them with black plastic or layers of newspapers during the growing season.

Chemical Control: Herbicide use is not recommended to control nonnative species on grasslands or savannas where there are native prairie plants. However, herbicide may be required on severely degraded areas or where prairie restoration is beginning. In such cases, the herbicide glyphosate has proven effective when used according to label recommendations. Herbicides which selectively target grasses and other monocots may also be used with caution.

References

Boudreau, Denise and Gary Wilson. "Buckthorn Research and Control at Pipestone National Monument," *Restoration and Management Notes* (Wisconsin). 10:1, Summer, 1992: 94-95. Also, *Thirteenth North American Prairie Conference*, pp. 161-164.

Brown, Lauren. *Grasses: An Identification Guide.* Houghton Hifflin Company, Boston, Massachusetts, 1979.

Chadde, Steve W. *A Great Lakes Wetland Flora*. Pocketflora Press: Calumet, Michigan, 1998.

Courtenay, Booth, and James H. Zimmerman. *Wildflowers and Weeds: A Field Guide in Full Color*. Fireside; Simon & Schuster Inc. New York, 1992.

DeLoach, Jack C. "Past Successes and Current Prospects in Biological Control of Weeds in the United States and Canada ," *Natural Areas Journal*. Vol. 11 (3), 1991: 129-141.

Delroit, R.L. *An Illustrated Taxonomy Manual of Weed Seeds*. Agronomy Publications: River Falls, WI, 1970.

Dittberner, Phillip L., Donald R. Dietz, Clinton H. Wasser, et al. "Autumn Olive (*Eleagnus umbellata*)," *U.S. Army Corps of Engineers Wildlife Resources Management Manual*. U.S. Army Corps of Engineers: Washington, D.C., February 1992: Section 7.5.7.

Doll, Jerry. "Controlling Canada Thistle," *North Central Regional Extension Publication*. Iowa State University: Ames Iowa, No. 218.

Doll, Jerry. "Multiflora Rose: Friend or Foe?" *Agronomy Advice*. UW-Madison Agronomy Department: Madison, Wisconsin, FC 38.1.

Doll, Jerry. "'Noxious' Weeds in Wisconsin", UWEX, Agronomy Department, 1575 Linden Drive, University of Wisconsin-Madison, 53706.

Doll, Jerry. "Results of Wisconsin Noxious Weed Survey'" UWEX, Agronomy Department, 1575 Linden Drive, University of Wisconsin-Madison, 53706.

Doll, Jerry. "Weed Laws in Wisconsin State Statutes," UWEX, Agronomy Department, 1575 Linden Drive, University of Wisconsin-Madison, 53706.

Egan, Dave and Steve Glass. "EZJECT System Fails to Control Buckthorn," *Restoration and Management Notes* (Wisconsin).

Eldred, Gary. "Aspen Control on Prairie Remnants." Gary Eldred: Boscobel, WI.

Evans, J.E. "A Literature Review of Management Practices for Multiflora Rose," *Natural Areas Journal*. Vol. 3, No. 1: 1983.

Field, Ronald J. and Wilma A. Mitchell. "Bush Honeysuckles *(Lonicera* spp.)," *U.S. Army Corps of Engineers Wildlife Resources Management Manual*. U.S. Army Corps of Engineers: Washington, D.C., January 1988: Section 7.5.5.

Flack, Stephanie and Elaine Furlow. "America's Least Wanted," The Nature Conservancy . November/December 1996: 17-23.

Gelber, Debra and William D. Schneider. 1995. *Naturalized Non-native Plants and Environmental Health in Michigan: A Comparison of Expert Field Knowledge with Exiting Public Policy*. School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI.

Glass, Steve. "Experiment Finds Less Herbicide Needed to Control Buckthorn," *Restoration and Management Notes* (Wisconsin). 12:1, Summer, 1994: 93.

Gleason, Henry A., and Arthur Cronquist. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. Second Edition. The New York Botanical Garden, Bronx, New York, 1991.

Grese, Robert E. *The Landscape Architect and Problem Exotic Plants*. pp. 7-15.

Harrington, Robin Ann. "Photosynthesis and Growth of Exotic and Native Shrubs in Open and Understory Habitats in Southern Wisconsin." Ph.D. Thesis, UW-Madison, 1987.
Heidorn, Randy. "Vegetation Management Guideline: Exotic Buckthorns--Common Buckthorn (*Rhamnus catharica* L.), Glossy Buckthorn (*R. frangula* L.), Dahurian Buckthorn (*R. davuria* Poll.)," *Natural Areas Journal* , Vol. 11 (4), 1991: 216-217.
Hermsen, Elizabeth and Kelly Kearns . "The Invaders," *The Niche*, Vol. 10 No. 1 . Bureau of Endangered Resources, DNR. Winter 1997: 1, 3.
Hoffman, Randy, and Kelly Kearns, editors. *Wisconsin Manual of Control Recommendations for Ecologically Invasive Plants*. Bureau of Endangered Resources, Wisconsin Department of Natural Resources: Madison, Wisconsin, May 1997.
Illinois Vegetation Management Guidelines. Illinois Nature Preserves Commission: Springfield, Illinois, 1990.
"Impacts of Invasive Exotic Plants." Position Statement, Exotic Pest Plants Councils.
Invasive Alien Plant Species of Virginia. Virginia Native Plant Society and Department of Conservation and Recreation.
"Invasive Plant Information Sheets." The Nature Conservancy, Connecticut Chapter and Connecticut Department Environmental Project.
Iowa Noxious Weeds. Iowa Department of Agriculture and Land Stewardship: State of Iowa.
Irea, John J. Jr. "The Philosophy, Procedure, and Cost of Developing a Classical Biological Control of Weeds Project," *Natural Areas Journal.* Vol. 11 (3), 1991: 143-147.
Kearns, Kelly. "Green Alien Hordes Invade Forests, Prairies, Wetlands!" *Wisconsin Natural Resources.* June 1996: 4-9.
Kearns, Kelly . "Spotlight on Ecological Weeds: Dame's Rocket *(Hesperis matronalis*)," *The Niche*, Vol. 9 No. 2 . Bureau of Endangered Resources, WDNR. Summer 1996: 10- 11.
Kirkwood, R.C., and L. Archibald. “The rhizome as a target site for the control of bracken using foliage-applied herbicides.” In *Bracken. Ecology, Land Use and Control Technology. Proceedings of the International Conference, Bracken 1985.* R.T. Smith and J.A. Taylor, eds. Lancashire, UK:Parthenon Publishing, 1986. Pp. 341-350.
"Leafy Spurge Biology and Control," Agronomy Advice . UW-Madison Agronomy Department: Madison, Wisconsin, FC Ref. 38.1.
Lowday, J.E. “A comparison of the effects of cutting with those of the herbicide asulum on the control of bracken.” In *Bracken. Ecology, Land Use and Control Technology. Proceedings of the International Conference, Bracken 1985*. R.T. Smith and J.A. Taylor, eds. Lancashire, UK:Parthenon Publishing, 1986. Pp. 359-368.
Lym, Rodney G., Calvin G. Messersmith, and Richard Zollinger. "Leafy Spurge Indentification and Control." North Dakota State University Extension Service: Fargo, North Dakota, November 1993.
Lym, Rodney G. and Richard K. Zollinger. "Spotted Knapweed." North Dakota State University Extension Service, June 1992.
Nyboer, Randy. "Vegetation Management Guideline: Bush Honeysuckles--Tartarian, Morrow's, Belle, and Amur Honeysuckles," *Natural Areas Journal*. Vol. 12 (4), 1992.
Pauly, Wayne R. "How to Manage Small Prairie Fires." Dane County Parks Commission: 4318 Robertson Road, Madison, WI 53714. 1982.
Post, Thomas W. and Elizabeth McCloskey. "Glossy Buckthorn Resists Control by Burning." *Restoration and Management Notes* (Indiana). Vol. 8, No. 1, Summer, 1990.
Randall, John M. and Janet Marinelli, Eds. *Invasive Plants: Weeds of the Global Garden*. Brooklyn

Botanic Gardens, Inc., Handbook, 1996.
Reinartz, James A. and Joanne Kline. "Glossy Buckthorn (*Rhamnus frangula*), a Threat to the Vegetation of Cedarburg Bog," The University of Wisconsin--Milwaukee *Field Station Bulletin*. Vol. 21, No. 2, Fall 1988: 20-35.
"Report and Recommendations of the Minnesota Interagency Exotic Species Task Force", submitted to the Natural Resources Committee of the Minnesota House and Senate, April 1991.
Rice, P.M. and J.C. Toney. "Plant population responses to broadcast herbicide applications for spotted knapweed control," *Down to Earth*. Vol. 51, No. 2, 1996: 14-19.
Robinson, R. "Practical herbicide use for bracken control." *Bracken. Ecology, Land Use and Control Technology. Proceedings of the International Conference, Bracken 1985*. R.T. Smith and J.A. Taylor, eds. Lancashire, UK:Parthenon Publishing, 1986. Pp331-340.
Schwegman, John. "Exotic Invaders." *Outdoor Highlights*, Mid-March issue, 1988: 6-11.
Sedivec, Kevin, Thomas Hanson, and Cindie Heiser. "Controlling Leafy Spurge Using Goats and Sheep." North Dakota State University Extension Service: Fargo, North Dakota, May 1995.
Smith, Tim E., ed. *Missouri Vegetation Management Manual*. Missouri Department of Conservation: Jefferson City, Missouri, 1993.
Solis, Ken and Ann Mackenzie. *Park Surveyor's Guide*. The Park People: Milwaukee, Wisconsin., 1996.
Stein, Bruce A. and Stephanie R. Flack. *America's Least Wanted: Alien Species Invasions of U.S. Ecosystems*. The Nature Conservancy: Arlington, Virginia, 1996.
Swenson, William A."Clear Boats, Clean Water--STOP the Exotic Species Invasion." UW Extension: UW-Superior, 1995.
Swink, Floyd, and Gerould Wilhelm. *Plants of the Chicago Region.* Indiana Academy of Science, The Morton Arboretum, Lisle, Illinois, 1994.
Szafoni, Bob. "Multiflora Rose," *Vegetation Management Circular*. Vol. 1, No. 15. Illinois Nature Preserves Commission, Illinois Department of Conservation.
U.S. Congress Office of Technology Assessment. *Harmful Non-Indigenous Species in the United States*. OTA-F-565 U.S. Government Printing Office: Washington, D.C., September, 1993.
Uva, Richard H., Joseph C. Neal, and Joseph M. DiTomaso. *Weeds of the Northeast.* Comstock Publishing Associates of Cornell University Press: Ithaca, New York, 1997.
Vitousek, Peter M., Carla M. D'Antonio, et al. "Biological Invasions as Global Environmental Change," *American Scientist*. Vol 84: 468-478.
Voss, Edward G. *Michigan Flora*. Cranbrook Institute of Science, Bloomfield Hills, Michigan, 1972.
Walters, Cathy. "Wisconsin's Exasperating Exotics," Newsletter of the Wisconsin Chapter of the Nature Conservancy, Winter 1992.
Wasser, Clinton H. and Phillip L. Dittberner. "Smooth Brome (*Bromus inermis*) ," U.S. Army Corps of Engineers Wildlife Resources Management Manual . U.S. Army Corps of Engineers: Washington, D.C., July 1986: Section 7.1.1.
White, Barbara A. "Selection of Protective Clothing for Use in Pesticide Application" and "Decontamination Procedures for Pesticide-Contaminated Clothing," Leafy Spurge Database.
Williams, Ted. "Invasion of the Aliens." *Audubon*, September/October 1994: 24-32.
Williams, Ted. "Killer Weeds." *Audubon*, March/April 1997.

Appendix

Tools for Weed Control

Large-Scale Swiper Bars: Swiper bars are useful in selectively applying herbicides. Easy to make, the bars are designed for use in one of two ways, held in the hand or mounted on the front of a four-wheeler during spraying. Design plans, by Melvern C. Hoff and Herman H. Jensen of Illinois, are available from:

Bureau of Endangered Resources
WDNR
P.O. Box 7921
Madison, WI, 53707
Phone: (608) 267-5066.

Root Jack: Root Jack is an easy-to-use, hand-operated device which will effectively uproot woody plants, culling out those that are one and a half inches or less in diameter. It can be used to yank many common invasives from the soil, including the noxious brome and spiny thistle. Contact:

Michael Giacomini
P.O. Box 726
Ross, CA 94957
Phone: (415) 454-0849.

Weed Wrench: The Weed Wrench™ is a manually-operated tool designed to remove woody plants by uprooting with minimal disturbance of the soil and surrounding vegetation. Able to be wielded by people of average strength, the wrench is a safe, efficient, permanent way to remove unwanted invasives that shrubs and trees. For more information, contact:

Tom Ness and Sophia Sparks
5517 Riverbanks Road
Grants Pass, OR 97527

Useful References and Resources

Draft Lists of Exotic Plant Species Invasive in Continental United States. Exotic Pest Plant Councils, 8208 Dabney Avenue, Springfield, VA 22152. Phone: (202) 682-9400.

"Element Stewardship Abstracts," written for the most troublesome ecological weeds for use by The Nature Conservancy staff. Contact: The Nature Conservancy, 1815 North Lynn Street, Arlington, VA 22209. Phone: (703) 841-5300. Also on the web: http://www.tncweeds.ucdavis.edu

"Foreign Invasive Plants of Wisconsin's Wooded Areas" is a short brochure which includes photographs to identify Wisconsin's most threatening invasives and a brief list of hints on how the landowner can be rid of them. For a copy of this pamphlet, contact: Ken Solis, 4700 W. Grange Avenue, Greenfield, WI 53220. Large quantities are available at cost.

"Implications of Exotic Pest Plants" is a brief article which describes a litany of afflictions wrought on the environment by the encroachment of unwelcome exotic flora. To receive a copy, contact: Bureau of Endangered Resources, Wisconsin DNR.

"Invasive Plant Species to Avoid" is a list of common, potentially invasive plants in Wisconsin, detailing the common and scientific nomenclature for each. To receive a copy, contact: Bureau of Enadangered Resources, Wisconsin DNR.

"Invasive Weeds: A Growing Pain" is a colorful poster on one side, a valuable aid for teachers on the other. This glossy, graphic print from the Federal Bureau of Land Management not only illustrates common floral invasives with bold photographs, but gives tips for the educator on how to present the problem of encroaching invasives in simple and fun ways for children. For a free copy of the poster, contact: Bureau of Endangered Resources, Wisconsin DNR.

"Native Plant Nurseries and Restoration Consultants" is a compilation of the names and descriptions of various businesses and individuals who deal with native landscaping in southern Wisconsin. Included in the list are sources from which to buy plants or seed, companies which plan and install vegetation, and advisors and planners who can be contacted for aid in restoration projects. To receive a copy, contact: Bureau of Endangered Resources, Wisconsin DNR.

Natural Areas Association Compendium on Exotic Species consists of 43 articles from the Natural Areas Journal compiled into a looseleaf binder ($20) Natural Areas Association, 320 South Third Street, Rockford, IL 61104.

"'Noxious' Weeds in Wisconsin," "Weed Laws in Wisconsin State Statutes," and "Results of Wisconsin Noxious Weed Survey" are all articles on Wisconsin invasives by Jerry Doll.

Avaiable through UWEX, Agronomy Department, 1575 Linden Drive, University of Wisconsin-Madison 53706. Phone: (608) 262-1391.

PMIS (Noxious and Nuisance Plant Management Information System): This CD- ROM provides descriptions of and tips on controlling 34 different species of noxious and nuisance weeds. Set up to run under the Windows@ platform, this software includes numerous illustrations and full-color photographs, all made easily accessible by the point-and-click format for information retrieval. Copies of PMIS are available free of charge while supplies last. Contact: Michael J. Grodowitz, U.S. Army Corps of Engineers, CEWES-ER-A, 3909 Halls Ferry Road, Vicksburg, MS 39180. Phone: (601) 634-2972. FAX: (601) 634-2398. E-mail: grodowm@mail.wes.army.mil.

Pulling Together: National Strategy for Invasive Plant Management is a short booklet on how to prevent the infestation of native habitats by invasives, how to control invasives once they are established, and how to restore native ecosystems to their more pristine original state. Available in large quantities. Contact: Sean Furniss, MS 670, 4401 North Fairfax Drive, Arlington, VA 22203. E-mail: Sean_furniss@mail.fws.gov.

Replacing Invasive Plants with Native Species is a binder put together by the Greendale Environmental Group, which, as the title suggests, details tactics by which the landowner can replace invasives on his or her property with the native flora of Wisconsin. Written in a clear, easy-to-comprehend manner, this compilation should be especially handy for the non-professional. Contact: Ann Mackenzie, 5969 Sugarbush Lane, Greendale, WI 53129-2624. Available at cost.

Journals and Organizations Providing Invasive Plant Information

Canadian Journal of Plant Science publishes an excellent series on the weeds of Canada, many of which are also problems in the United States.

Conservation Biology is the journal of the Society for Conservation Biology.

Federal Interagency Committee for the Management of Noxious and Exotic Weeds. Contact: Sean Furniss, MS 670, 4401 North Fairfax Drive, Arlington, VA 22203. E-mail: sean_furniss@mail.fws.gov.

Field Station Bulletin, the University of Wisconsin-Milwaukee, 3095 Blue Goose., Saukville, WI 53080.

National Coalition of Exotic Pest Plant Councils, 8208 Dabney Avenue, Springfield, VA 22152. Phone: (202) 682-9400 extension 230. FAX: (202) 2682-1331.

Natural Areas Journal, Natural Areas Association, 320 South Third Street, Rockford, IL 61104.

The Nature Conservancy produce "Element Stewardship Abstracts" for the worst of the invasive plant species. Contact: The Nature Conservancy, 1815 North Lynn Street, Arlington, VA 22209. Phone: (703) 841-5300.

Restoration and Management Notes, Society for Ecological Restoration, 1207 Seminole Highway, Madison, WI 53711. Phone: (608) 262-9547.

The Spurge Society has been formed to fight the spread of leafy spurge and publishes a newsletter. The editor of the *Leafy Spurge News* is Russell Lorenze, 1924 North Grandview Lane, Bismarck, ND 58501.

Weed Science, *Weed Technology*, and *Weed Research* are all journals primarily oriented to agricultural weeds, but occasionally contain articles about plants which are ecological invaders.

Ecological Weed Control Publications

"Element Stewardship Abstracts," written for the most troublesome ecological weeds for use by TNC staff. The Nature Conservancy, 1815 North Lynn St., Arlington, VA 22209. (703) 841-5300.

Illinois Vegetation Management Manual, Illinois Nature Preserves Commission, 524 South Second Street, Lincoln Tower Plaza, Springfield, IL 62706. (217) 785-8686.

Missouri Vegetation Management Manual, Tim Smith, editor, Natural History Division, MO Department of Conservation, PO Box 180, Jefferson City, MO 65102. (314) 751-4115 ext. 200.

Natural Areas Association Compendium on Exotic Species, 43 articles compiled from the *Natural Areas Journal.*

Karner Blue Butterfly References

Forest Management Guidelines: Developing Management Plans Compatible with Karner Blue Butterfly Persistence, written by Cynthia Lane for the WIDNR and USFWS as part of the Karner blue butterfly HCP, Bureau of Endangered Resources, WIDNR, Madison, WI.

Wildlife Management Guidelines for the Karner Blue Butterfly, written by the Wisconsin DNR Karner Blue Technical Team as part of the HCP, Bureau of Endangered Resources, WIDNR, Madison, WI.

Wisconsin Karner Blue Butterfly Habitat Conservation Plan, Volume 1, written by the Wisconsin DNR and the HCP Partners, Bureau of Endangered Resources, WIDNR, Madison, WI.

[C] Amendment C